The Vegetable oil industry in the Bombay presidency by Yuill.

PREFACE.

While he was Assistant Controller, Oils and Paints, under the Indian Munitions Board, Lieutenant A. F. Yuill kindly gave the Department of Industries much valuable assistance and advice in dealing with a large number of enquiries regarding the vegetable oil industry. It was then suggested to him that he might collect and compile the available information regarding oil seeds, oils, machinery and other subjects bearing on the possibilities of the vegetable oil industry in the Bombay Presidency. Lieutenant Yuill very kindly consented to undertake this task for which he was exceptionally qualified by reason of his scientific training, his practical experience of the vegetable oil industry in America and India and the opportunities for investigation which his appointment under the Indian Munition Board afforded him. Unfortunately several causes have delayed the publication of the bulletin. The result is that, in some details, statistical information is not up to date. This does not impair however, the practical value of the bulletin, which is published in its original form except for some slight alterations which could be made without further delaying publication.

The subject is treated in a practical manner based on current practice and the bulletin should be of great value to all who are interested in the industry. The author shows clearly that the expansion of the vegetable oil industry depends, not merely on the provision of more plant, but on the existence of favourable economic factors efficient technical supervision and sound and enterprising business management.

An interesting proposal is made for a system of standardisation The views expressed on this and other matters are those of the author and while the Department of Industries cannot now officially pronounce upon these views, it will welcome the interest and discussion which the expression of them will promote.

The Department of Industries is under a deep obligation to the author for his generosity in placing his experience and knowledge freely at the disposal of the department and in sacrificing much spare time in the work of compiling this bulletin.

R. D. BELL,
Director of Industries.

Bombay, 10*th May* 1921.

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THE VEGETABLE OIL INDUSTRY IN THE BOMBAY PRESIDENCY.

CHAPTER I.

INTRODUCTION.

In recent years it has been frequently asked why the vegetable oil industry in India is not more widely established and more prosperous than it is and whether more active interest and assistance by Government would not stimulate its development. To assist his department to answer these questions and to deal with the practical problems of the industry, the Director of Industries, early in 1920, invited the writer to make a comprehensive survey of the conditions in the Bombay Presidency. In submitting this report, for which no terms of reference were laid down, the writer hopes that it will not only be useful for departmental purposes, but that, if its publication is considered to be desirable, the practical information which it contains may be of assistance to those who are engaged in the industry or who are considering its commercial possibilities.

In order to arrive at a correct estimate of the situation, a careful survey of existing oil-pressing equipment has been carried out, and the size, importance, and efficiency of the vegetable oil industry of this Presidency has been carefully compared with those of the same industry in more highly developed countries such as France, the United Kingdom and America. The results will be found tabulated in Chapter II.

Secondly, a careful survey of all existing and easily available supplies of raw materials has been made. Each of the prominent oil seeds, available in commercial quantities within the Presidency, has been carefully studied and the prospects of its development from an oil-pressing point of view have been considered; the possibilities of finding profitable outlets in India and elsewhere for the products of an expanded industry have been investigated; attention has been drawn to favourable and unfavourable factors in

the situation, while the question of the best location and equipment for factories, which may in future be erected to deal with each of the different kinds of oil seeds, has not been neglected. The results of these and other investigations are detailed in Chapter III.

In Chapter IV various types of machinery, used in oil-milling in India and elsewhere, are described in detail, and comparisons of their suitability for Indian conditions, their efficiency, outturn, capital costs, and working expenses are given so that prospective purchasers may not have to rely entirely on advertising literature or on the advice of interested salesmen.

In Chapter V the results of a careful survey of the efficiency of existing methods of oil expression are tabulated, explained and commented on.

Chapter VI is devoted to the subject of oil refining, or the further treatment of crude oils in order to render them less liable to become rancid, and to make them more suitable for use in India or for export to those countries which at present import India's oil seeds. Existing methods or want of methods are also examined, and compared with the methods in vogue in other countries.

The problem of finding new uses in India for the products of an expanded industry is discussed at some length in Chapter VII.

As the success of an oil industry in the Bombay Presidency is mainly contingent on the establishment of an export trade in such of the products as cannot be utilised in India, an attempt is made in Chapter VIII to point out the necessity for improvements in marketing methods, in the type of containers in which oil for export should be packed, and for the establishment, either by Government or by private agency, of standards of quality for each of the oils, the export of which it is intended to encourage. Particulars of a standardisation scheme which is considered to be worthy of the attention of provincial departments of industries are detailed in the same chapter.

Appendices include :—

(1) A list showing the average oil content of each of the important oil seeds available within the Presidency,

(2) A list of the principal manufacturers of oil mill machinery in Europe and America with, where known, the names of their local agents.

(3) A bibliography of the best books available on the subject of vegetable oil manufacture and refining.

(4) Extract from a Memorandum submitted to the Committee on Edible and Oil Producing Nuts and Seeds (1916) by Prof. Crowther of the University of Leeds, showing the average oil content of some oil cakes availabe in England.

(5) Extract from "Feeds and Feeding" by Henry & Morrison (1907) showing average oil content of some oil cakes available in the United States of America.

(6) Extraction of oils by solvents (from the Oil and Colour Trades Journal of March 19, 1921).

CHAPTER II.

Position of the Vegetable Oil Industry in the Bombay Presidency and a comparison with that of other Countries.

In normal years more than two-thirds of India's oil seed ex passes through Bombay and Karachi, while of her very much sm export of oils, less than two per cent. passes through the same p The exports of oil from Presidency ports are therefore small compared with exports of oil seeds. This will be seen f the figures for 1913-14, *i.e.*, a normal pre-war year.

Table I.

Particulars of exports from Bombay to all countries during twelve months ending 31st March 1914.

	Tons.	Weight per cent.	Value Rs.	Value per cer
Oil seeds (non-essential) total ..	842,000	= 100	12,42,00,000	= 1(
Oils (non-essential) ,, ..	700	= ·08	3,61,000	=

Table II.

Particulars of exports from Karachi to all countries during the same period.

	Tons.	Weight per cent.	Value Rs.	Value per cen
Oil seeds (non-essential) total..	224,000	= 100	3,83,00,000	= 10(
Oils (non-essential) ,, ..	100	= ·04	49,000	= ·:

The corresponding figures for the nine months ending December 1919 are given below :—

Table III.

Particulars of exports from Bombay to all countries during nine months ending 31st December 1919.

	Tons.	Weight. per cent.	Value Rs.	Val per c
Oil seeds (non-essential) total ..	274,000	= 100	8,63,00,000	= 10(
Oils (non-essential) ,, ..	3,500	= 1·29	28,90,000	= 3·3:

Note.—Nearly 3,000 tons of cocoanut oil, previously imported from other provinc Bombay, were in this period re-exported to Europe. After deducting this exceptional item, the of oil is only 2 per cent. of the weight of oil seeds exported in the same period.

TABLE IV.

Particulars of exports from Karachi to all countries during the nine months ending 31st December 1919.

	Tons.	Weight per cent.	Value Rs.	Value per cent.
Oil seeds (non-essential) total ..	188,000	= 100	4,73,00,000	= 100
Oils (non-essential) ,, ..	70	= ·04	68,000	= ·15

The following statements show the approximate quantity of oil contained in the manufactured articles imported into Bombay and Karachi during the same periods, as well as the total weight of oil seed which would be required to furnish the same.

TABLE V.

Imports into Bombay during twelve months ending 31st March 1914.

Articles.	Total weight.	Approximate oil content weight.	Representing finished products of exported oilseeds.	Per cent. of total seeds exported.
	Tons.	Tons.	Tons.	
1. Candles ..	200	100		
2. Oil, vegetable ..	1,400	1,400		
3. Oil cloth ..	200	20		
4. Paints and colours ..	5,318	265	(say) 15,000	1·78
5. Soap ..	7,000	3,500		
6. Sundries ..	100	50		
	14,218	5,435	15,000	1·78

In other words, the manufactured articles imported into Bombay represented only the oil extracted from 1·78 per cent. of the seed exported from Bombay during the same period.

TABLE VI.

Imports into Karachi during 12 months ending 31st March 191

Article.	Total weight.	Approximate oil content weight.	Representing finished products of exported oilseeds.	Per ce of tot seed export
	Tons.	Tons.	Tons.	
1. Candles	*Nil.*	0		
2. Oils, vegetable ..	170	170		
3. Oil cloth ..	*Nil.*	0	(say) 2,700	1
4. Paints & colours ..	855	43		
5. Soap	1,349	674		
6. Sundries	50	25		
	2,424	912	2,700	1

TABLE VII.

Imports into Bombay during nine months ending 31st December 19

Article.	Total weight.	Approximate oil content weight.	Representing finished products of exported oilseeds.	Per ce of tot seed export
	Tons.	Tons.	Tons.	
1. Candles	19	10		
2. Oils vegetable ..	294	294		
3. Oil cloth ..	44	4	say 9,500	3
4. Paints & colours ..	3,954	200		
5. Soap	5,455	2,700		
6. Sundries	100	50		
Total ..	9,866	3,258	9,500	3

TABLE VIII.

Imports into Karachi during nine months ending 31st December 1919.

Articles.	Total weight.	Approximate oil content weight.	Representing finished products of exported oilseeds.	Per cent. of total seeds exported.
	Tons.	Tons.	Tons.	
1. Candles	*Nil.*	0		
2. Oil, vegetable ..	48	48		
3. Oil cloth ..	7	1	(say) 1,500	·8
4. Paints & colours ..	488	24		
5. Soap	726	363		
6. Sundries ..	50	25		
Total ..	1,319	461	1,500	·8

The disturbing effect of the war appears to have done little to improve the situation, and, failing a rise in the standard of living, the increased demand for oil which might be expected to result from the stoppage of all imports of such materials and their manufacture in India, would not be more than sufficient to warrant the erection of one oil mill of moderate size, or to increase by 15 per cent. the outturn of the existing machinery.

Oil Imports into Bombay.

On the other hand there is a very considerable import of oil into Bombay Presidency from other provinces, *e.g.*, cocoanut oil from the west coast of Madras, groundnut oil from Eastern Madras, rape and mustard oils from the United Provinces, and linseed oil from the Central Provinces. Against this, exports of oils from the Bombay Presidency to other Provinces are inconsiderable, and the total excess of imports from other provinces over exports thereto may be reckoned at not less than 8,000 tons per annum, representing the oil yield of approximately 20,000 tons of oil seeds and nuts. The greater portion of this oil is imported into Bombay

city for consumption there, or for despatch to the mofussil, a much of it is so superior to the oil expressed locally that it realise higher price, *e.g.*, Cochin cocoanut oil imported by sea is super to and realises a higher price than oil expressed locally from co similarly imported. In the case of certain other oils, such as groun nut and castor from the Madras Presidency, the market rates of imported oils are lower than those of locally manufactured oils similar quality. In none of the districts from which these oils imported is the oil pressing machinery superior to that available Bombay, practically the whole of it being the output of coun ghanis and rotary mills. In spite also of the obviously grea expense of transporting the oil over the cost of transporting the bearing materials, these oils are able more than to hold their o against oil of local manufacture.

Present position as regards Equipment.

At the present time there are scattered throughout the Bomb Presidency a number of oil mills equipped with fairly mod hydraulic machinery, with daily outputs varying from two to fi tons of seeds per day. These crush castor seed, linseed, cot seed, groundnuts, etc. The potential daily output of these m may be taken to be about 150 tons of seeds. There are also expell with a potential output of 25 tons per day, rotary ghanis worked oil engines with a potential output of say 200 tons per day of hours, and ordinary bullock ghanis capable of crushing about tons per day of 12 hours. This gives a total existing crush capacity of approximately 500 tons per day or say 150,000 tons annum. It is doubtful, however, whether the actual weight of se crushed in the Presidency is much in excess of 100,000 tons annum. This is about 9 per cent. of the total available, so t for every ton of seed crushed locally 11 tons are sent overseas raw materials.

It is evident, however, that there is already in the Presider sufficient oil pressing machinery not only to supply all existing requirements, even if there were no imports from other provinc

but also, if need be, to produce all the oil required for the manufacture of those imported products mentioned in Tables V, VI, VII and VIII.

Position of the Industry in other Countries.

Before attempting to account for the existing state of affairs it will be interesting and instructive to consider the position of the oil crushing industry in other countries, *e.g.*, in the United Kingdom, France and the United States.

Taking first the United Kingdom in a pre-war, a war and a post-war year, the total imports of raw materials, and consequently the weight of seed crushed were as under :—

Table IX.

United Kingdom.

	1910. Tons.	1914. Tons.	1919. Tons.
Total imports of oil seeds, nuts and kernels into the United Kingdom.	1,549,400	1,482,600	1,689,500

The average, excluding war years, would appear to be over one and a half million tons, of which not less than one million tons were less oily seeds such as cotton seed and linseed. The import and expression of richer oil bearing material has however increased considerably during and since the war, and arrangements are at present being made for considerably enlarging existing plants, and for building additional factories in different parts of the United Kingdom to meet the increased demand for oils and fats for margarine manufacture. When these are complete, the annual requirements of the oil mills of the United Kingdom will be not less than two million tons.

Table X.

France.

	1908.	1913.	1919.
Total imports of oil seeds and kernels (approximately).	700,000	628,450 (Marseilles only.)	454,500

The nominal requirements of French oil mills would appe to be not far short of 1,000,000 tons per annum, most of whic consisting mainly of richer oil bearing material, such as copra an groundnuts, are crushed at Marseilles.

TABLE XI.

United States of America.

	1918. Tons.
Total weight of seeds, etc., used in oil pressing industries in 12 months.	4,845,000 (approximatel

The above total includes approximately 4,000,000 tons c cotton seeds, which is about the average quantity of that see crushed annually in the U. S. A. during recent years. Excludin linseed, which accounts for more than half of the balance, th industry concerned with the crushing of the remaining oil seeds an kernels, though expanding, is relatively unimportant.

Comparison with Bombay Presidency.

It is apparent, therefore, that, while a fairly large proportion c the oil seeds treated in other countries is grown within the limits c the Bombay Presidency or is shipped from Presidency port the vegetable oil industry of the province compares, in mere siz unfavourably with that of other countries.

CHAPTER III.

Detailed consideration of the Oil Seeds available in the Bombay Presidency.

The principal oil seeds exported from Bombay and Karachi in normal years in order of their importance are :—

Linseed, cotton seed, rape seed, sesamum, castor seeds and groundnuts.

In 1913-14 the exports of these seeds from this Presidency were :—

	Tons.
Linseed	214,000
Cotton seed	279,000
Rape seed	241,000
Sesamum	107,000
Castor seeds	100,000
Groundnuts	54,000

During the years 1919-20 and 1920-21 exports from the same ports were :—

	1919-20. Tons.	1920 21. Tons.
Linseed	114,000	83,000
Cotton seed	241,000	99,000
Rape seed	120,000	180,000
Sesamum	45,000	11,000
Castor seeds	7,000	14,000
Groundnuts	36,000	13,000

Linseed (*Botanical name* Linum Usitatissimum).

Linseed is not extensively crushed in the Bombay Presidency. At the outside, the total weight crushed annually does not exceed 9,000 tons, the yield of oil from which probably amounts to a little over 3,000 tons. The cakes are mostly exported as there is little demand for them in this or any part of India. The oil is used in certain parts for edible purposes, but chiefly either raw or boiled for mixing with paints. The requirements of the Presidency for this oil, either as oil or in manufactured articles, probably do not

xceed 5,000 tons per annum, hence any considerable expansion of he industry would necessitate the export of both the products.)uring recent years, and particularly during the war, there has been n increasing export of linseed oil from India, chiefly from Calcutta,) Australia, New Zealand, South Africa and the East Indies. So ır Bombay has lagged far behind Calcutta, but there appears to be no articular reason why this Presidency should not be able to compete n equal terms with Bengal and to obtain a share of the export usiness which, during 1918-19, amounted to over 6,500 tons. The ıachinery in use in Bengal is similar to that in use throughout ıis Presidency, and practically the whole of the cakes produced ıere have also to be exported. In view of the fact that the oil cakes roduced will have to be exported, and that English importers :quire a cake not too poor in oil, the Anglo-American type of ıachinery appears to be most suitable, while the best location ›r oil mills appears to be in the vicinity of the chief ports. 'he chief difficulty which new manufacturers will have to face the absence of any recognised standard of quality for oils ıarketed in Bombay. Failing the establishment of a suitable 'stem of grading and inspection, the manufacture and export of ıseed oils, whether raw or boiled, could only be *undertaken by large ncerns* who would themselves be in a position to organise a rigid 'stem of standardization, so that importers in other countries ight be able to depend on the quality of oils purchased from them. s regards Bengal, this has already been done by concerns like the ourepore Company, Howrah Oil Mills, etc., and possibly other ss deserving concerns reap the benefit, but in Bombay no such andard exists and, while the product of at least one concern is of ıfficiently high grade to meet every possible requirement of such standard, much of the remainder is of very inferior quality. This ›plies to both raw and boiled oils, but more particularly to the tter.

Owing to the uncertain quality of the oils offered in the Bombay arket, ordinary commercial firms are chary of dealing in them, ıd in consequence much valuable business is lost to this side of ıdia.

Linseed cake being so greatly in demand in the United Kingdom and other European countries for feeding purposes, no difficulty need be anticipated in disposing of the cakes even if the whole of the seeds now exported should eventually be crushed in Bombay. Any advantage obtainable from the establishment of the crushing industry in this Presidency will be industrial rather than agricultural, and its success as an industry will depend entirely on the ability of Indian concerns to do the work cheaper or better than it can be done in Europe. Crushing costs per ton of seed in Europe are remarkably low. Previous to the war, in the large oil mills of England, which cost less than £1 per ton of annual crushing capacity to build and equip, linseed was crushed and the resulting oil filtered and packed, all at a cost of less than £1 per ton of seed and English crushers were then quite satisfied with a profit of five shillings per ton of seed. Possibly the cost has now more than doubled. The present cost of crushing linseed in India varies from Rs. 15 per ton in rotary ghanis to Rs. 25 or over in factories equipped with Anglo-American machinery. In heavily protected countries like France, Germany and Italy, which, previous to the war, imported considerable quantities of linseed, the products of Indian mills would have to face further handicaps in the form of protective duties equivalent to an additional crushing expense of £1 per ton of seed. All foreign manufacturers, moreover, have this great advantage over the oil producer in India, that the overseas freight for seed, which is easily packed and transportable, is lower than that for oil and oil cakes. It may seem, at first sight, that the disadvantage in freight rates and the foreign protective duties on oils, might be counterbalanced by the imposition of export duties on raw Indian linseed, but the fact that India, though a large exporter, has not a monopoly of linseed production, renders an export duty ineffective for this special purpose.

Cotton seed (*Botanical name* Gossypium Herbaceum).

Much has been written regarding the desirability and possibility of establishing a cotton seed crushing industry in India, and much more has been written with the object of explaining away

the want of success which has so far attended the various attempts to establish it, particularly in Bombay. The success of the American industry has been contrasted with the failure of the Indian, and its failure has been variously attributed to inferior organization, faulty selection of machinery, bad business or technical management, and last but not least, the failure of the Indian cultivator to know what is good for him and for his cattle. One of the most noticeable facts in connection with the recent history of the Indian cotton seed trade is the increasing popularity of cotton seed as a food-stuff for cattle, particularly for milch cattle. Trade returns show that during the five years preceding the war, the total exports of cotton seeds from Bombay exceeded one million tons, practically all of which went to England; while during the five years ending 1918-19 the total export did not exceed 300,000 tons. There was no falling off in production, and in spite of the fact that the export of approximately 700,000 tons of seeds had been lost during the period of the war, stocks in India at the time of the armistice were lower than at the same date in 1913, and the market rate of the seed was between 60 per cent. and 70 per cent. higher than the pre-war average. During the five years in question, practically the whole production of Indian cotton seed had been utilized in India, partly as seed but chiefly for cattle-feeding.

The editor of an influential English trade paper commented on the trade returns for June 1919 as follows :—

> " One slightly reassuring feature appears in the June returns and that is the arrival of 3,218 tons of cotton seed from India. This is the first arrival of Indian cotton seed which has occurred since 1917, during which year we received 8,436 tons from that country. Does it mean that at last the trade is to be allowed to make some use of the large quantities of cotton seed produced by our great dependency ? "

These remarks were apparently made under the impression that the English oil industry was being prevented from obtaining available supplies, and that, as the same writer stated a month previously, the stocks of cotton seed were *piling* up in India. The fact of the matter is that, in addition to being an oil-seed, cotton seed is a very useful cattle food which will be utilised as such, unless crushers,

whether English or Indian, are prepared to pay for it at a higher rate than the Indian cultivator is prepared to pay for it as food for his cattle. The Indian cultivator is not willing to accept cotton seed cake as a substitute for the whole seed, and it has yet to be proved that he is wrong in so doing. It is just probable that the oil, which is present in Indian seed to the extent of 16 per cent. to 17 per cent. of the total weight of the seed, is not wasted but acts as a slight laxative and enables larger rations of the seed to be fed without any untoward effect, such as would result from attempts to feed similarly large rations, particularly of decorticated cotton seed cake. At any rate, it is a question for the Agricultural Department to investigate and to prove, by careful and extended feeding trials, the correctness or otherwise of this cherished belief of the Indian cultivator, whose faith in the efficacy of cotton seed is only equalled by his disbelief in the virtue of cotton seed cake. Should the result of careful investigation prove that the Indian cultivator has been misguided, figures should be published showing the parity at which it will pay the cultivator to exchange his cotton seed for cake, or to substitute the one for the other in his feeding rations. It is only fair to state that Indian cotton seed, with its scantier covering of lint, thinner and more digestible shell and better balanced food value, is a better food-stuff than American cotton seed with its firmly adhering lint, tough hull and greater oil content, and that it has much better keeping properties than cotton seed cakes, whether these are decorticated or undecorticated. Being an article capable of utilization either as a food-stuff or as an oil seed, it follows that its market rate will fluctuate in sympathy with both these markets and, while in the case of other oil seeds there is a direct relation between the cost of the raw materials and the rates realised for the oil and *vice versâ*, in the case of cotton seed there is no such relation.

During the period of the war, when it was impossible either to export cotton seed cake to Europe or to dispose of it profitably in India, the cost of manufacturing one ton of oil from cotton seed was far higher than the cost of manufacturing the same weight of oil from groundnut, and to establish itself as an article of Indian commerce, cotton seed oil should sell at about the same rate as the

best quality of groundnut oil. Both oils are used for the same purposes, and neither have any specific virtues such as are possessed by the oils obtained from castor and linseed. Roughly speaking, to enable cotton seed and groundnut oils to approximate in cost, the market rate for cotton seed should not be more than two-sevenths of the market rate for the same weight of groundnuts, *i.e.*, 7 cwts. of cotton seed should not cost more than 2 cwts. of groundnuts. So long as this relation is maintained, the crushing of cotton seed will be profitable and capable of expansion. Variation will result either in abnormal profits or in abnormal losses to those engaged in the business. It will be apparent, therefore, that as far as India is concerned the business is likely to prove highly speculative, and to require the provision of larger capital than would be required for engaging to the same extent in the business of crushing other varieties of oil seeds. A more highly qualified, and, therefore, more expensive technical staff is required for the successful working of a cotton seed oil mill than is necessary in the case of a mill equipped for crushing other kinds of oil seeds.

Owing to the difficulty which is experienced in disposing of cotton seed cake in India, and the fact that cotton seed hulls, which comprise 50 per cent. of the weight of the undecorticated cakes are readily saleable locally, it will be advisable at the outset to equip Indian cotton seed oil mills with decorticating, pressing and even refining machinery such as is in use in the United States, rather than with the type common in England. Such mills, however, on account of their very limited press room equipment are not suitable for economically crushing other oil seeds such as linseed and groundnut.

In England most of the cotton seed is crushed without decortication or removal of the hulls, and the machinery required for this method of treatment is equally suitable for crushing linseed. Later on, when the Indian demand for cotton seed cake is sufficiently large to obviate the necessity for export, it may pay better to instal machinery capable either of making undecorticated cotton seed cakes or of crushing linseed. It will be seen from the foregoing that, for the present at least, cotton seed crushing in India *is*

not likely to prove a success as a small scale industry, and, as the bulk of the cake will for some time require to be exported, mills should be built as near as possible to a port. As the local demand for the products improves, the establishment of mills in the interior may become advisable and further advantages may result from the introduction of the American system whereby the mills produce only crude oil which is shipped in tank cars to a central refinery, suitably equipped for the proper treatment of the oil and the recovery of all the by-products. It is doubtful, however, whether the American system whereby the crushing mills are independent concerns, selling their crude oil to the refining companies, would be practicable in India.

As, for the present at any rate, the cake produced would have to be exported, and the oil to be sold in competition with oils like groundnut either in Europe or India, it follows that success in this industry will depend to a large extent on the ability of the Indian crushers to crush the seed economically; to obtain the best results as regards oil yields, utilization of by-products, etc.; and to manufacture products equal, if not superior, to those prepared in Europe and America.

NOTE.—A comparison of the relative market rates for cottonseed and groundnuts shows that, at the time of writing, cottonseed crushing is or should be a highly profitable business.

Rapeseed (*Botanical name* Brassica Campestris).

Comparatively little rapeseed is either grown or crushed in Bombay Presidency. Most of the exports, therefore, which before the war averaged over 200,000 tons a year, were brought by rail from the Punjab and the United Provinces to Karachi and Bombay for export to Europe. In 1913-14 the countries to which exports were made were, in order of their importance, Belgium, Germany, France, Great Britain, Italy, Austria-Hungary and Holland. Rapeseed is grown and extensively crushed in most European countries where the oil is used for edible purposes, for tempering steel, for the preparation of compound lubricants, and for lighting purposes. The total quantity crushed in Europe is, however, considerably less than that crushed in India. In India approximately one million tons of rapeseed are crushed annually, chiefly in Bengal and the

The total import into Bombay of rapeseed oil being barely 100 tons per annum, there is little prospect of a local expansion of the industry unless new uses can be found for the products, or an export market can be developed. In other parts of India, rapeseed oil is used for edible and toilet purposes. In this Presidency, however, its place for edible purposes is taken by sweet oils such as sesame, groundnut, kardi, etc., and the use of oil for toilet purposes is not general. Even if deodorized, it is doubtful if rape oil would find favour, or partially displace any of the oils just mentioned. The only probable opening for the extended use of rape oil in this Presidency would be in the manufacture of compound lubricants, and it is doubtful whether the quantity which could be utilized in this way is at all considerable.

Rapeseed is the one oil seed of which India has practically a monopoly and the questions arise whether, under a protective or preferential fiscal system, the imposition of an export duty on the seed would not stimulate an export trade in oil in replacement of the export trade in seed, and whether the Bombay Presidency should not be able to share in the consequent expansion of the rape oil industry. The main question involves a careful study of foreign markets and other conditions some of which are outside the scope of this report. An export tax alone would not create a local rape oil industry which, even under a protective scheme, would require very careful organisation.

For the establishment of the industry locally the installation of additional machinery would be necessary. For a small scale installation it is probable that rotary ghanis or expellers would prove most economical. For large concerns the cage type of press, specially adapted for pressing small seeds, would be more suitable, especially for the production of cold drawn oils. Such oil would be eminently suitable for the preparation of deodorized rape oil, now largely used in Europe for edible purposes. They would also, when required, be suitable for crushing other oil seeds. Anglo-American presses might be used for the second pressure. The advantages of a benzine or other solvent extraction process for removing the oil left by the first or cold pressure are worth investigation, but as there is little

data available regarding the working of solvent extraction plants in hot countries like India, the installation of such a plant, without further trial, cannot be definitely recommended. Whether the crude oil is obtained by cold or hot pressure, in hydraulic presses, by rotary ghanis or by extraction, it is necessary that it should be carefully freed from impurities and refined to the standard required in Europe. For edible purposes, refining with solutions of caustic or carbonate of soda and salt, followed by washing, drying and treatment in deodorizers would be necessary. For other technical purposes, purification might be effected by the sulphuric acid process which, however, would not be admissible if the oil were required for the manufacture of lubricants. The industry of oil refining might well be carried on in places like Bombay and Karachi, even if the oil were manufactured in the seed producing districts.

For the shipment of the oil to European markets strong steel containers would be necessary, and although these would entail extra expense they would probably pay in the long run. Very careful standardization of oil for export is essential and if the industry is unable to establish its own system of standardization, it should be considered whether Government can arrange for the grading and certification of all rape oils offered for export. The necessity for such standardization is shown by the fact that large American oil concerns, who use rape oil for preparing compound lubricants and import their requirements from Europe, are at present unable to make use of the inferior oils now manufactured in India. The cost of crushing in this country is quite as high as it is in Europe and the cost of shipping oils, including the cost of containers, is higher than the cost of shipping seeds. In most European countries, except England, the oil produced in India would also be handicapped by having to pay import duties varying from £0-2-3 in the case of Norway to about £0-6-0 in the case of France and Germany. The cake also is one for which there is not much demand except from Germany, and the excess resulting from any expansion of the industry, would have to be sold very cheaply in order to find a ready local market.

Sesamum or Tilseed (*Botanical name* Sesamum Indicum).

In normal years nearly 75 per cent. of India's total production of this seed is utilized in this country for the manufacture of sweet or edible oil, and only about 25 per cent. of the crop is exported. In the Bombay Presidency, approximately 50 per cent. is utilized, and the remainder, *viz.*, about 20,000 tons, is exported from Bombay, along with about 80,000 tons received by rail from Rajputana, Central India, United Provinces, Central Provinces and Hyderabad. The exports in pre-war years went chiefly to Belgium, France, Germany, Austria, and Italy, *i.e.*, those European countries, the laws of which demand that, for identification purposes, margarine should contain a certain fixed proportion of sesamum oil.

In the Bombay Presidency the seed is crushed chiefly in country ghanis, and the oil obtained is consumed locally with the exception of about 500-600 tons which are annually exported from Bombay to oriental markets, *e.g.*, Persian Gulf, Aden, Ceylon, Natal, Mauritius. Owing to its firm hold on popular favour, sesame oil is in great demand and fetches a higher price than any other sweet oil. Groundnut, kardi and cottonseed oils are, however, replacing sesame to a certain extent, and the former at least is considerably cheaper. In view of the fact that, for the purposes for which it is used in India, groundnut and cotton seed oils serve equally well, it is doubtful whether it is worthwhile trying to increase the local demand for the oil. Nor would it be advisable to attempt to extend the crushing industry in this country by imposing export duties on the seed. India has no actual or virtual monopoly of the seed supply, and such a course would merely result in lowering the returns of the ryot by the amount which the European importers have to pay in export duties. Most of the European countries which import sesamum are protectionist countries. While admitting the seed free, they impose duties of approximately £0-5-0 per cwt. on the imports of oil. In the face of such a handicap, combined with the higher cost of transporting the oil compared with that of transporting seed, the establishment of a successful crushing industry in Bombay and an export trade in oil will not be a very easy matter.

On the other hand, there is no reason why a well equipped Indian industry should not be able to obtain a market for sesame oil in some of the countries, which do not penalise the import of oil. Belgium, which in 1913-14 took nearly one-third of the sesamum exported from India, Holland, which imports considerable quantities, and the United Kingdom, which took over 20,000 tons in 1916-17, all admit oil free or practically free of duty.

The Indian method of production, *viz.*, expression in country or rotary ghanis, yields to none either in point of quality or of cost, and it is doubtful whether it will pay to instal expensive hydraulic machinery for pressing this seed. Except in the case of cold drawn oil obtained by first pressing either in cage or Marseilles presses, the oil produced in hydraulic presses is darker, more bitter and otherwise inferior to the oil produced in ghanis. It is after and not during expression that the bulk of the Indian oil is spoiled. Failure to effect a prompt separation of the oil and mucilage results in excessive development of acidity, and the absence of facilities for drying and filtering the oil are responsible for the cloudy and dirty appearance of much that is offered in the bazaar. Provision of these facilities for treating the oil obtained by pressing in ghanis, and careful attention to the question of both seed and oil storage, would result in a decided improvement in the quality of all oils produced in India. If sesame oil, treated as above, could be collected at central refineries, and treated for the purpose of reducing excess acidity, it is probable that an export trade in sesame oil might be established without the necessity of erecting any extra crushing mills.

On the other hand, if there is any doubt about the possibility of obtaining supplies of oil of absolute purity, it would become necessary for firms seeking to establish an export trade to arrange for their own pressing facilities. On a small scale rotary ghanis would probably provide the best oil and at the lowest rate per ton of seed, but on the large scale preliminary cold pressing in cold presses, and second pressing in rotary ghanis would be more suitable. Refining equipment for reducing the acidity, for washing, drying, filtering and deodorizing would be essential, and all the oils should be carefully tested and standardized before export.

Owing to the fact that sesame oil is by law required to be used in all margarine made in most of those countries which are at present importing sesamum, and that in the highest grades of margarine the use of liquid oil such as sesame oil is not desirable, it is probable that margarine makers would favour the introduction of hydrogenated sesame oil, which would enable them to use larger quantities of this excellent oil without injuriously affecting the melting points of their products. Hydrogenation does not interfere with the reaction by means of which sesame can be detected in mixtures of other oils and fats. This appears to be one of the instances in which hydrogenation might be profitably employed in connection with the Indian oil industry and, if all the sesame oil exported were sufficiently hydrogenated to give a product solid at ordinary temperatures, one of the chief difficulties of transport would be successfully overcome.

Castor seed (*Botanical name* Ricinus Communis).

Practically the whole of the castor seed produced in the Bombay Presidency is now crushed locally. The castor seed exported from Bombay is chiefly Hyderabad seed which has been brought in by rail. A considerable quantity of castor seed is crushed throughout the Presidency in country ghanis, but Ahmedabad is by far the most important pressing centre as far as castor oil is concerned, just as Guzarat is the most important castor seed growing division. Most of the mills in Ahmedabad are equipped with complete hydraulic plants chiefly of the Anglo-American type, although one or two have also cage presses of the Premier type. Hot drawn oil is produced and double pressing is the rule. A good yield of the oil is obtained although it is doubtful whether the slightly increased yield obtained by this method compared with that obtained by using rotary ghanis compensates for the increased crushing cost. Rotary ghanis give only slightly inferior results as regards oil yields and, as far as ordinary hot drawn oil is concerned, equally good results as regards quality. They are low in first cost, and when driven by crude oil engines can be operated at a cost between Rs. 15 and Rs. 16 per ton of seeds. Owing to their low output, the cost of

crushing castor seed in country ghanis is probably much higher an there are no compensations either in the way of increased yield c superior. quality.

Expellers are unsuitable for the expression of oil from castc seed. The hard shells of the seed quickly wear away the central worr and other parts of the machine, and the cost of renewals is excessive

For the production of large quantities of cold drawn oil, suitabl for pharmaceutical purposes or for aeroplane engine lubrication, cag presses are essential. The resulting cakes can afterwards be broke up, tempered and repressed or extracted with solvents. The latte method has not yet been tried on a commercial scale in India, but i is used in England and other continental countries. Provided th technical difficulties due to climatic condition can be overcome, ther seems to be no reason why the method should not prove satisfactor in India. An interesting point in connection with this process is th fact that the extracted powder is said to have lost its poisonous pro perties, and to be capable of being used as a cattle food.

Only about 25 per cent. of the oil produced in the Bombay Presi dency is of really good quality. The remainder is usually excessivel acid and is imperfectly purified before leaving the mills. As th quality of the oils obtained after the monsoon is usually inferior t that obtained between harvest time and the beginning of the mon soon, it is feared that the use of badly stored seed is in part at least th cause of the increased acidity. Other causes are want of cleanli ness in and around the mills leading to contamination of the oil, an want of facilities for effecting the separation of the oil and the mucil age. Much might be done to improve the quality of the castor oil b improving the clarifying equipment of existing mills.

Failing an increased castor seed crop within the province which is unlikely, expansion of the industry would necessitate th importation of raw material from outside. At present Hyderabac (Deccan) supplies the bulk of the castor seed which passes through Bombay to Europe, and instead of establishing new mills in Bombay it might be more economical to establish oil mills for crushing castor

seed in Hyderabad State itself, and to rail the partly clarified oil to Bombay for further treatment prior to its export to Europe. The cake produced ought to find a market in the state itself, or in other parts of the Deccan. There is little or no demand for the cake in Bombay, and if mills were erected in Bombay the resulting cake would probably have to be railed back again to the Deccan. The preparation however of better qualities of cold pressed oil, such as are required for pharmaceutical purposes, for lubricating aeroplane engines or for making compound lubricants requires greater care in manufacture, more elaborate plant and more efficient supervision than would be obtainable in the Deccan rural districts. Mills for the preparation of such oils as well as refineries for treating the partly clarified oils prepared elsewhere might be erected in Bombay.

An export trade in high grade castor oil could also be more conveniently established by Bombay firms. Uniformity of quality, and an efficient system of grading are necessary if an export trade in castor oil is to be established and maintained.

Before the war the exports of castor seeds were chiefly to the United Kingdom which took about half the total quantity exported, to the United States, which took nearly one quarter, and to France, Belgium, Italy and Germany. During the war exports to the last three countries fell off considerably or stopped altogether. Since the conclusion of peace, exports to the United Kingdom also have greatly diminished but as soon as the Home Government's surplus stock of castor oil has been worked off, there should again be a good demand from that country, either for seed or for oil, and an excellent opportunity for establishing an export trade in oil instead of in seeds will present itself.

Groundnuts (*Botanical name* Arachis Hypogaea).

Compared with Madras which accounts for 75 per cent. of the Indian groundnut crop, Bombay's production of this oilseed is relatively unimportant. Still it amounts to between 50,000 and 100,000 tons per annum, about 20,000 tons of which are utilized for edible purposes within the province, or are exported to northern India for the same purpose. The balance, of approximately 50,000

tons, per annum is available for crushing or for export. In norm years about 20,000 to 30,000 tons are crushed within the Presiden limits, and the balance together with about 20,000 tons import from other provinces is exported to Europe.

Before the war the exports went chiefly to France, Belgiun Germany and Austria. Recently the exports to the United Kin dom have increased very considerably, while exports to oth countries have fallen off.

Groundnuts are crushed locally by means of hydraulic presse expellers, rotary ghanis and country ghanis. Owing to the absen of hydraulic plants suitable for preparing cold drawn oil, the be quality of oil is not prepared in such mills. The cost of crushir groundnuts in hydraulic mills is not less, and probably more, tha Rs. 25 per ton, and with double pressing the average yield fro the shelled nuts is nearly 40 per cent. Expellers alone, or in con bination with rotary ghanis, produce a good quality of oil, but are t expensive both in first cost and maintenance. Double pressing necessary to obtain a normal oil yield. Ghanis, rotary and countr though slightly less efficient as regards oil yield, are cheapest first cost, are capable of producing the best oil with the least amou of skilled attention and, particularly in the case of rotary ghani are by far the cheapest to maintain and run. They however lea more oil in the cake than is economically advisable. Failure clarify properly oils obtained by the last two methods is probab responsible for the inferior quality of much of the groundnut obtainable in the bazaars. This is to be regretted as the clarific tion of groundnut oil is easily effected, and the plant required neither complicated nor expensive.

In addition to the oil produced within Presidency limits, abo 4,000 tons of this oil are yearly imported from other province Very little groundnut oil is exported from Bombay. Although Bon bay's production and export of groundnuts is small compared wi that of Madras, the groundnut crushing industry is capable of cons derable expansion. To supply the oil imported from other pr vinces would utilise 10,000 tons of the quantity available for expo

d would occupy 150 rotary ghanis throughout the year. The mand for groundnut oil from other oriental countries is increasing d probably offers a better chance of expansion than trade with rope. Trade with Europe depends on the ability of the Indian dustry to produce economically oils of equal or even better quality an those presently prepared from Indian nuts in Europe. The velopment of an export trade in groundnut oil to protectionist untries will be almost impossible. In the case of free trading untries like England, however, the prospects are better. During cent years the United Kingdom has been importing about 130,000 140,000 tons of groundnuts annually of which less than one fifth is imported from India. There is also a fairly considerable import to England of groundnut oil chiefly from France, China, Burmah, :. One or two mills equipped for pressing 20,000 tons of ground- its per annum ought to find no difficulty either in obtaining sup- ies of nuts or in disposing of the products, which, it is probable, ould for a time have to be exported to England. Profitable work- g, as in the case of crushing linseed, would depend on the care ercised in maintaining the quality of the products, on a satisfac- y oil yield, and on the exercise of the strictest economy in regard working expenses.

Minor Oil Seeds.

Poppy seed (Papaver Somniferum).

In normal years considerable quantities of poppy seed are import- into Bombay from the United Provinces and Rajputana and are nce exported chiefly to France for the manufacture of high class ad oils, etc. In 1913-14 about 17,000 tons were so exported, ile during 1920-21 the export was only 4,000 tons. It is ubtful whether any considerable success is likely to result from empts to utilise the seed in this country. France is the chief suming country, and oils produced in India and exported reto would have to pay an import duty of about £0-6-0 per cwt. ich is equivalent to an additional expenditure of Rs. 15 on every 1 of seed crushed in this country.

Niger seed (Guizotia Abyssinica).

Prior to 1914-15 there was an annual export of this seed of about 4,000/5,000 tons chiefly to France and the United Kingdom. Recently the exports have dwindled considerably, and during the past year they did not exceed 400 tons. It is evident therefore that this seed, the total outturn of which may exceed 20,000 tons per annum, is already being utilized within the province. Most of the seed is produced in the Deccan, and is crushed in country ghanis, the oil being utilized for edible purposes. The only improved variation from present practice that can be suggested, is that rotary ghanis driven by oil engines should be substituted for the country ghanis driven by bullocks. This would effect a considerable economy in crushing costs, and set free both men and bullocks, the labour of which is badly required in other industries.

Safflower (Carthamus Indicus).

About 15,000 to 20,000 tons of this oil seed are produced annually, chiefly in the Deccan districts. As there are no records of any exports it would appear that the whole of the crop is at present utilized within the province, and the remarks made regarding the limited scope for introducing improvements in manufacture in regard to niger seed, apply equally in regard to this oil seed.

Cocoanut or Copra (Cocos Nucifera).

Although the cocoanut palm is fairly extensively grown along the western coast of the Presidency, very few of the nuts are used for the preparation of cocoanut oil. About 5,000 tons of this oil are produced annually within the province from copra imported chiefly from the Malabar coast and Ceylon. The oil produced is consumed locally with about 4,000 tons of oil imported chiefly from Cochin. Apart, therefore, from the inferiority of the available supplies of copra as compared with the quality of the copra which in Cochin is used for preparing the well known Cochin cocoanut oil, there would appear to be little reason why the whole of the cocoanut oil required in the Presidency should not be prepared in the Province. In view of the recent development in the method of

refining cocoanut oil it ought to be possible to produce, even from available supplies of copra, oils equal in quality to those imported from Cochin. The copra crushed in Bombay is treated chiefly in rotary ghanis, and by this method of manufacture the oil left behind in the cake is greater than appears to be necessary, so much so, that the cake offered for sale by some crushers contains nearly as much oil as Indian cotton seed, and might probably pay for further treatment in hydraulic presses or for extraction by means of solvents. The oils obtained would, however, only be useful for soapmaking.

Forest Products.

Mowrah seed (Bassia Latifolia).

In the year 1913-14 nearly 30,000 tons of this seed were exported from Bombay chiefly to Germany and Belgium. Last year the exports totalled only about 1,000 tons. The actual crop varies somewhat from year to year but not to this extent. It is evident, therefore, that like most other forest products mowrah seeds are collected only when there is a demand for them. The season also for collection is very short, *viz.*, from the middle of May till the break of the monsoon, and unless previous arrangements are made a large proportion of the crop becomes spoiled and is lost to commerce. Of the portion which is actually collected a considerable proportion produces rancid oil, owing to having been stored through the monsoon without having been properly dried previously. There is considerable room, therefore, for improvement of the arrangements for the collection and disposal of this valuable forest product. In view of the known shortage of higher melting point oils suitable for the manufacture of soap and candles, and the high prices which are being paid for such oils in Europe, if the difficulties regarding collection, treatment and storage of the seed could be overcome, it should be possible to establish a profitable export business in mowrah oil to other than protectionist countries.

At present a small quantity of this seed is crushed for local use in hydraulic presses, rotary and country ghanis. By the use of hydraulic presses about 33 per cent. of oil is obtained. In view of the valueless nature of the mowrah cake this result cannot be

considered to be entirely satisfactory. It is possible that b results might be obtained by extracting the ground seeds benzine or other solvent and utilizing the extracted meal for purposes. Any extraction or other plant, the produce of which intended to export, should be erected as conveniently as possib the port from which the product is likely to be shipped.

Other forest products, not at present utilized to any extent, which are worth attention are :—

(1) The seed of Vateria Indica (yielding Malabar tall
(2) Garcina Indica (yielding kokam butter).
(3) Calophyllum Inophyllum (yielding domba oil).
(4) Mauritia Vinefera (yielding Maruti fat).
(5) Melia Azirdarakhta (yielding nim oil).
(6) Pongamia Glabra (yielding karanj oil).
(7) Salvadora Olerides (yielding kakan fat).

CHAPTER IV.

Description and Comparison of various types of Oil Mill Machinery and Equipment.

The means employed in the production of vegetable oil are chiefly mechanical. Chemical methods, such as extraction with solvents, are also being used to some extent, but the weight of material so treated at present is small compared with the weight treated by mechanical methods. Of mechanical methods, expression in hydraulic presses is by far the most important, particularly in the West. In oriental countries, however, a considerable quantity of oil is still produced by mechanical means in other than hydraulic equipments. Many of these mechanical devices are crude and wasteful, while others are surprisingly effective. Even in the West, the supremacy of the hydraulic press has from time to time been challenged by the introduction of oil milling machinery employing mechanical methods of pressure transmission and application. Machines of this type, *e.g.*, the expellers, though often offering considerable advantages, such as continuous operation and reduced working expenses, have, however, never been able to stand up, for a prolonged period, to the excessively hard work involved in oil milling. The chemical or solvent system of oil extraction, which offers several distinct and substantial advantages over mechanical systems, is likely to become, and remain a much more formidable rival.

Hydraulic Systems.

Machinery utilising hydraulic methods of pressure application may be roughly subdivided as under :—

(1) American types such as are used for the treatment of cotton seed.

(2) Anglo-American types such as are used in England and on the continent of Europe.

(3) American types such as are used for the treatment of linseed and other small seeds.

(4) Cage or clodding types, used chiefly on the continent of Europe.

American Cotton-seed Oil Mill Machinery.

It is probable that this type of American machinery heads the list of hydraulic equipments, as regards numbers of press units, if not of actual outturn. Over two and a half million tons of cotton seed kernels, equivalent to nearly five million tons of cotton seed are treated annually in such presses and, as crushing operations in America only last about five or six months in a year, the total annual capacity of this type of machinery must be not less than five million tons.

The preparatory machinery employed is adapted for removing dirt, foreign substances, and excess lint; for bringing about an effective separation of the kernels and husks; for rolling the former to break down the oil cells; for bringing the oil bearing material to the correct condition as regards heat and moisture and for effecting its transfer to the presses. Except that more ample cooking capacity is provided, the machinery up to this stage is similar in principle, if not in detail, to all preparatory oil mill machinery. The presses however are peculiar. They are fitted with plates, which resemble boxes, the two ends of which have been removed. The spreading of the cooked kernels is prevented by the resistence of the sides, and spreading from the ends is prevented by the fold of the press cloth. For dealing with decorticated cotton seed, such types of presses are very satisfactory, but, should it be found necessary to change over and work other types of oil seeds their disadvantages soon become apparent. Owing to the great thickness (about 2 inches) of each of the built up box plates, a press of this type will only deal with about three-fifths of the quantity of oil bearing material per operation which could be dealt with by a flat plate press of similar size. This means that a plant listed to treat say 40 tons of cotton seed per day, only 20 tons of which are actually dealt with in the presses, would treat about 20 tons of other oil bearing materials, such as linseed, as compared with not less than 30 tons which could be treated under the same conditions in an Anglo-American mill of similar size. This loss in production raises the operating costs and may in some cases, renders the whole operation unprofitable. This fact must be taken

into consideration when comparing the costs of different types of machinery. Each full size American press holds about 1¾ cwts. of cooked cotton seed kernels which in turn represents nearly 3 cwts. of Indian cotton seed. Three pressings per hour is as much as can be satisfactorily accomplished, so that each press represents a productive capacity of 9 cwts. of cotton seed per hour or about 10 tons per day. Its capacity for dealing with linseed or other material requiring to be once pressed would only be about 5 cwts per hour or 5½ tons per press per day of 22 hours. Excluding expenditure on erection, housing and power plant, the cost of machinery for a mill of this type, at present rates of exchange, would be approximately Rs. 50,000 per 10 tons daily capacity when treating cotton seed or per 5½ tons capacity when treating linseed, that is, about Rs.1,10,000 per ton hour capacity for pressing cotton seed and Rs. 2,00,000 per ton hour, for single pressing linseed or other small seeds.

Equipments of this type are working satisfactorily in this Presidency. The average percentage of oil left in Indian decorticated cotton seed cakes, after expression in such presses, is between 9 and 10. There are, however, American records of cakes from similar presses showing less than 6 per cent. of oil, but such results are the exception rather than the rule. The working expenses of crushing cotton seed in a mill of this type should not exceed Rs. 20 per ton. For crushing other oilseeds such as linseed, the cost per ton is about 50 per cent. higher. Such mills, without the addition of extra machinery, are quite unsuitable for the treatment of seeds or nuts like castor, groundnuts, etc., which, for best results, require to be pressed, first cold and afterwards hot.

Anglo-American Oil Mill Machinery.

As far as actual outturn is concerned, this type of machinery is probably ahead of the American type. Most of the English oil mills are equipped with such machinery, as also are a considerable number of oil mills on the continent of Europe and elsewhere. The name Anglo-American is however somewhat of a misnomer, the only part of the equipment which resembles closely its American counterpart being the rolls. The plant usually consists of cleaning

and preparatory machinery suited to the material which is to be treated; a stack of heavy chilled rolls; cooking kettles; steam or hydraulic cake forming machinery; hydraulic presses of the corrugated plate type; belt driven hydraulic pumps connected to accumulators which in turn operate the presses; cake paring machines and edge runners for grinding up the parings and press sludge, for finely grinding material such as undecorticated cotton seed or for re-grinding once pressed material to prepare it for repressing.

These edge runners have long been the most distinctive part of the Anglo-American equipment and they are perhaps the most useful machines which can be installed in any oil mill. It would appear however that there has lately been a tendency on the part of manufacturers of oil mill machinery to discard these most useful machines and to substitute for them cake breaking and disintegrating machines.

Anglo-American machinery will treat in a fairly satisfactory manner almost every known oil bearing material from comparatively dry seeds like cotton seed or soya beans to very oily materials such as castor-seed and groundnuts. It is suitable for single pressing materials such as undecorticated cotton-seed or linseed, or for the double pressing of groundnuts, castor-seed, etc. It will be apparent, therefore, that this type of plant is particularly suitable for use in countries which have to import their raw materials and for manufacturers who have a choice of many different kinds of oil-seeds, all of which they wish to treat in the same plant. Anglo-American plants are built in various sizes. The smallest will crush about 10 tons of seed per day, while mills of this type to crush over 1,000 tons of seed per day have been erected.

Except in the case of undecorticated cotton-seed cakes the oil content of which is usually under 5 per cent. or of the cake from double pressed materials such as castor-seed, groundnuts, etc., cakes from Anglo-American plants usually contain between 9 per cent. and 10 per cent. of oil. This is due to the fact that only limited pressure, *e. g.*, 18 cwts. to 20 cwts. per square inch can be applied to materials

which are not properly confined. The actual ram pressures employed in equipments of this type vary, however, from 35 to 40 cwts. per square inch, but as the area of the plates is twice the area of the ram, the actual pressures per square inch on the cakes are as stated above. In certain cases where trade customs demand a minimum oil content in the cake as, for example, in the case of linseed, Anglo-American machinery will be found quite suitable, while on the other hand, if oil yield is the only consideration, better results can be obtained by using specialised machinery of the cage type. Anglo-American plants are, however, unsuitable for the manufacture of cold drawn oil the demand for which for edible purposes is increasing. Certain oil-seeds such as tilseed cannot be satisfactorily treated in Anglo-American plants owing to the fact that the steam employed therein liberates colouring matter from the seed and the resulting oil is dark and inferior. Exclusive of housing, erection charges and expenditure on power plant, an Anglo-American plant of four presses with preparatory and finishing machinery will at present rates of exchange cost from Rs. 60,000 to Rs. 80,000. Such a plant being capable of treating per day of 24 hours about 22 tons of material requiring only once pressing, or about 12 tons of material requiring to be pressed twice, the cost per ton hour capacity will be about Rs. 75,000 for single pressing and Rs. 1,40,000 for double pressing.

In England, prior to the war the cost of treating linseed in mills of this type did not exceed £1 per ton of seed. Owing however to the rise in wages, increases in the price of coal, press cloths and other stores, it is probable that the present crushing cost is not far short of £2 per ton of seed. In India, on account of the small size of plants hitherto employed, neglect of the machinery and the consequent increase in the expenditure on press-cloth, the cost of once pressing seeds like linseed in mills of this type is not less than Rs. 25 per ton, while for double pressing seeds like castor, the cost per ton is not less and probably more than Rs. 30. In purchasing presses of the Anglo-American type, preference should be given to those, the plates of which are supported by means of lugs or screws resting on fixed side racks, rather than to those, the plates of which are supported from the press heads and each other by means of links. Equipments

provided with edge runners and double or continuous rather than single heating kettles are also preferable. Generally, single kettles only are provided, but with these the best results cannot always be obtained.

American Linseed Oil Mill Machinery.

This type of machinery is largely used in America for crushing linseed and other small seeds. It differs materially from the Anglo-American type only in the fact that edge running grinders are not provided. It is therefore unsuitable for the treatment of an oil bearing material which requires to be double pressed, or for the manufacture of cold pressed oil. The capital cost of an equipment of this type suitable for the treatment of less oily seeds such as linseed, will be practically the same as that of a cotton-seed oil mill containing the same number of standard sized presses. The capital cost per ton hour of crushing capacity will therefore be about Rs. 1,20,000. The cost of working will be similar to that of an Anglo-American oil mill. One advantage, however, possessed by this type of plant is in regard to the provision of sufficient cooking kettles for bringing the ground material into the best possible condition as regards temperature and moisture. American cooking kettles, particularly those operating on a continuous basis, are on the whole superior to the kettles usually provided by English makers. The lower percentage of oil left in American linseed cake as compared with that left in linseed cakes prepared in England, is probably the result not only of longer pressing, and higher pressures employed but also of better cooking, which in turn is due to the more generous cooking capacity provided by American plants. As, however, the English market demand is for a linseed cake containing nearly 10 per cent. of oil, no material advantage is to be gained by reducing the oil content far below that figure.

American Oil Mill Machinery, General.

Intending purchasers of American machinery should take the greatest care to ensure that the individual machines are sufficiently strong to stand up for a prolonged period to the continuously hard work and rough usage which they are likely to meet with

in this country. The American idea, that it pays to scrap even good machinery and buy improved models every five years, is probably responsible for the tendency of all but the very best American manufacturers to build machinery, the vital parts of which are far too light. In America, also, the majority of oil mills work only about five months of each year. There is therefore ample time for repair work, realignment of bearings and other adjustments. For India, however, machinery must be capable of working continuously and satisfactorily all through the year. Preference should also be given to those equipments which are provided with belt driven pumps and accumulators, rather than to those provided with direct steam driven hydraulic pumps, such as are generally supplied with small or medium sized mills.

Cage or Clodding Types of Press Equipments.

In all equipments of this type the material under pressure is effectively confined in cages or baskets either of perforated sheet iron or of iron bars correctly spaced and reinforced by circular hoops. Increased pressures up to about 3 tons per square inch can be utilised and heavy expenditure on press cloth is avoided. The cake residue is retained in the cage and the expressed oil is allowed to flow freely away. Very oily material can be treated either cold or hot in equipments of this type. If superior cold drawn oil is required, the material can first be treated cold and the residue, after regrinding, can be retreated hot. In this way the maximum quantity of best quality oil as well as the maximum yield from any material can be obtained. Preparatory machines of the usual type are provided as well as special machinery for pulverising the cake residue and preparing it for retreatment. Any kind of oil bearing material can be treated but, for the most satisfactory results, manufacturers should be told what oil-seeds are to be treated. They will then be able to arrange for the most satisfactory spacing of the bars of the cage, or size of outlets in the case of cages with perforated sheet metal sides. This type of equipment is not very largely used or manufactured in America where the bulk of the oil-seeds treated are of the less oily varieties. It is, however, largely used and manufactured on the

continent of Europe and to an increasing extent in the United Kingdom. Cage presses, manufactured by the leading English oil mill engineers are equal if not superior to any manufactured elsewhere, and there appears to be little to choose between the equipments manufactured by the different English firms whose names are shewn in Appendix No. 2.

The cage type of press equipment comprises :—

(1) Presses, the cage or barrels of which are not removeable from the press.

(2) Presses, the cages of which are made to revolve so that the material may be brought alternately over high and low pressure rams.

(3) Press equipments, the cages of which can be removed from the preparatory press on mechanical propelled trollies and placed in separate high pressure presses to complete oil drainage.

Fixed Cage Presses.

Presses of the first type, of which the Premier press manufactured by Messrs. Rose, Downs & Thomson, Ltd., and the Leeds press, manufactured by Messrs. Greenwood & Batley, Ltd., are examples, are generally placed beneath the heating or distributing kettle and the cages are never removed from over the ram. The removal of a false press head allows the material to be charged directly into the press. Iron plates are used for separating the cakes which, before pressure, are about 6 inches thick. The largest sized presses of this type have press rams 18 inches in diameter and are 9 feet deep. As each charge weighs about 5 cwt. a press equipment comprising two full size presses will have a crushing capacity of from 20 cwts. to 25 cwts. of material per hour if only one pressing is required, and twelve to fifteen cwts. if the material has to be twice pressed. This type of press, besides being the simplest, is also the most efficient. It is well known that material from which pressure has once been released re-absorbs oil, and cannot again, even under increased pressure, be made to yield its full oil content. As the pressure on material under treatment in cage presses of this type

is never released until the material is exhausted or ready for moval, better results should be obtainable with this than with other type. The cost of an equipment of this type comprising usual preparatory and re-treating machinery and two cage pres capable of double pressing an average of about 12-15 cwts. of mate per hour, will, at present rates of exchange, be from Rs. 80,000 Rs. 1,00,000, *i.e.*, about Rs. 1,40,000 per ton hourly crushing capac On account of the saving effected by dispensing with press cloth in labour charges, the cost of double pressing castor seed or other material in equipments of this type should not be greatly in excess Rs. 20 per ton of seed.

Revolving and other Cage Presses.

Presses of the second type, of which Lambert & Butler's pr manufactured by Messrs. Robert Middleton & Co., Ltd., and Crai patent revolving copra press are examples, are manufactured by sor but not all, of the leading English makers and are working in Eur and elsewhere with apparently satisfactory results. The same m be said of the third or battery type of press of which the Albion ty manufactured by Messrs. Manlove Alliot & Co. is an examp Unlike the other types of hydraulic presses previously mention which have been largely standardised, cage presses of the last t types are manufactured in a variety of styles, and it is probable tl the production of one manufacturer may be superior in certain respe to the product of others. For India, however, without further pra tical experience of their working under Indian conditions, th purchase cannot be recommended. With unskilled labour su as is obtainable in India there is a considerable risk in operating a kind of complicated machinery, but the risk is greatly increased whe as in the case of these types of presses, heavily loaded cages containi oil bearing material have to be transported from place to place befo being subjected to enormous pressure in other parts of the equipme

Combinations of Cage and Anglo-American Press Equipments.

Equipments utilising a combination of the fixed type of ca presses and Anglo-American presses are largely adopted for deali

with very oily seeds such as castor, copra, groundnuts, etc. The material is first treated cold, or nearly cold, in the cage presses where it yields about 75 per cent. of its oil content. The half pressed cakes are then broken up in disintegrators or ground in edge runners, and the ground material is transferred to the cooking heaters of the Anglo-American plant where, after being sufficiently heated and moistened, it is submitted to a second pressure in the Anglo-American presses. Such equipments are working satisfactorily in India, chiefly on castor seed, but they are also suitable for the treatment of copra, groundnuts and indeed of any material, the cold drawn oil from which is more valuable than hot drawn oil or in cases where market requirements demand a cake with a minimum oil content of nearly 10 per cent. The cost of an equipment of this type will at present rates of exchange be about Rs. 1,50,000 and as the hourly crushing capacity of the equipment will be about 25 cwts., the capital cost per ton-hour crushing capacity will be about Rs. 1,33,000.

Other Oil milling Equipments making use of Mechanical rather than Hydraulic Methods.

Equipments of these types are made in great variety and include amongst others

(1) Oil Expellers of which those manufactured by Messrs. V. D. Anderson Co., Frans Smulders and others are examples.

(2) The improved iron rotary ghani, largely used in India.

(3) The indigenous type of ghani, which in India is driven by bullock, ass, or camel.

Oil Expellers.

The sale of this type of oil press has been pushed very energetically in this country for some years. The results, however, either from the point of view of the manufacturer or of users cannot be considered to be entirely satisfactory. When sold at a reasonable price, expellers certainly have their uses, but that they also have equal limitations does not seem to be clearly recognised by those who

recommend their use. In the machine itself, which requires to be provided with the usual preparatory machinery, direct mechanical pressure or torsion of the material against the perforated or ribbed barrel and the resistence cone in front, is substituted for hydraulic pressure. When a certain pressure, usually about 3 tons per square inch, is exceeded, the exhausted material is forced out in thin sheets from the smaller end. The machine was originally introduced for the treatment of cotton seed, linseed and rapeseed. A number of cotton seed oil mills in Texas installed expellers about 15 years ago, but after a short time discarded them. They have, however, been found quite useful even if not economical on a small scale for the preparation of cold drawn varnish-making linseed oil. Owing, however, to the danger of prussic acid generation the cake produced in this way cannot be safely fed to animals without first being boiled. With all very oily seeds, such as rapeseed, groundnuts, copra, etc., double treatment is necessary. The first pressing may be carried out with cold or nearly cold material, yielding cold drawn oil, and the partially exhausted material can afterwards be ground up, heated, moistened and repressed yielding ordinary hot drawn oil. The oil yield by this method will be about equal to that yielded by the hydraulic press system. The outturn per machine, however, will be reduced to about 3 tons of oil bearing material per day of 24 hours, as compared with 5 tons per day for single treatment. Expellers are suitable and recommended for the first cold pressure of copra, and other soft materials, or for the re-treatment of materials partially treated in rotary mills, but they are unsuitable for treating undecorticated cotton seed and castor seed, the ground material of which contains hard particles. Excessive corrosion, due to the combined effect of the abrasive nature of such material wears away the worms and other vital parts of the machine and necessitates frequent and costly renewals. The present cost of a complete Anderson expeller equipment is about Rs. 24,000 per expeller without power or housing. (The cost of Anderson's expellers alone is about Rs. 14,000). The annual bill for renewals may run from Rs. 1,000 to Rs. 3,000 according to the seed treated. The outturn per day of 24 hours will be from 5 tons for material which will require one treatment, to 3 tons for material requiring double treatment. The

capital cost per ton hourly pressing capacity for single treatment will be Rs. 1,30,000, and for double treatment it will be Rs. 1,92,000. Working cost per ton of seed will vary from Rs. 12 to Rs. 20 per ton of seed, according to whether single or double treatment is required. It will be seen, therefore, that within certain limits expellers are useful machines, but from the limited success so far attained it does not appear likely that they will ever seriously threaten the supremacy of the hydraulic press system of oil extraction, or even replace the rotary ghani in the small oil mills of India. A Dutch firm, Messrs. Frans Smulders of Utrecht, manufacture an equally good expeller equipment. This is obtainable (1920) in Bombay at a price nearly 40 per cent. lower than that quoted above.

Improved Rotary Ghanis.

For small equipments in countries like India, no type of oil milling machinery offers so many advantages as that generally known as the " Improved Rotary Ghani ". Its simplicity enables it to be manufactured very cheaply in any foundry, and in dealing with most oil seeds it is surprisingly efficient. Mounted on a substantial framework foundation in batteries of ten, and driven by a crude oil engine, an equipment of this sort is low in first cost, can be run with the minimum of supervision and, gives results which compare quite favourably with those obtained by the use of expensive hydraulic machinery. The rotary ghani resembles to some extent a chemist's pestle and mortar, is under driven, and has an outlet for oil at the bottom of the mortar. Both pestle and mortar revolve, and the former is held tightly against the inside of the mortar by means of a chain and screw tightener. As the bowl of the machine revolves, the material under treatment is pressed between it and the pestle until the oil flows freely away. After being sufficiently pressed, the exhausted material rises to the top of the bowl, and can be removed by the attendant, who adds fresh material to replace that removed. Both the bowl and the pestle are scored in various ways to increase their effectiveness. If the working of the machine be carefully observed, it will be seen that the operations performed in one simple

machine correspond to the work ordinarily carried out on the large scale in the following preparatory and other machinery :—

(1) The disintegrators which break down the material to make it suitable for treatment in the rolls, where it is further reduced.

(2) Cooking heaters,

(3) Cake forming machinery,

(4) Presses hydraulic or otherwise,

(5) Regrinding machinery,

(6) Re-heating machinery,

(7) Re-pressing machinery.

The only preparatory machinery required is that dealing with the removal of foreign substances and, in the case of castor seed, for scalding the beans prior to treatment in the ghani. In small equipments, such as are commonly met with, such preparatory work is invariably done by hand. Rotary ghanis will treat satisfactorily, first cold and afterwards hot (as a result of the addition of some hot water), such oil bearing material as tilseed, rapeseed, groundnuts, copra and, in fact, most seeds which yield a liquid oil. It will also treat (after scalding with hot water) castor seed and the fat bearing nuts. A battery of 10 Ghanis will in 22 hours extract the oil from 5 tons of oil bearing material, and the actual cost of such an equipment, without power, will be about Rs. 5,000. The capital cost per ton hourly crushing capacity is therefore only Rs. 20,000. Even considering that both pestles and bowls require to be replaced every two or three years, the cost of crushing a ton of material in this type of oil mill does not exceed Rs. 16 per ton. It will therefore be seen that, compared with other types of oil mill machinery, such an equipment is very low, both in capital cost per ton hours of crushing capacity and in working expenses. Any one desiring to establish a small oil mill to treat up to 10 tons of castor seed per day of 24 hours would be well advised to consider the various advantages of this type of equipment before ordering expensive machinery from overseas.

The only disadvantages of this type of machinery are firstly, the fact that too much discretion is allowed to the operator and with careless workmen partially exhausted material containing an excess of oil may be removed from the machines at too early a stage of the operation, and secondly, the fact that it is impossible to obtain cold drawn castor oil from the treatment of castor seed in this type of equipment.

Country Ghanis.

The rotary ghani is, after all, only an improvement on the country ghani which is still very largely used through the country. Except that the mortar portion does not revolve, the working of the country ghani is similar to that already described but, owing to its low outturn, and higher working costs it is somewhat less economical as an oil producer. In certain cases, however, owing to the absence of iron in its construction, the oil produced is superior to that obtained from the same seed when pressed in rotary mills. Compared with the rotary mill its daily outturn is very low, *viz.*, only about 1 cwt. of oil bearing material per day of 24 hours. Owing to its low outturn the working costs per ton of seed are at least 50 per cent. higher than the working costs of a rotary mill. The advantages in increased output, efficiency, and reduced working expenses which would result from the substitution of rotary for country ghanis, might be brought to the notice of the local telis, and if necessary loans on easy terms might be granted to them to enable them to establish small rotary mills driven by oil engines in place of their present equipments.

Chemical Methods of Oil Extraction.

In view of the fact that few factories using this type of equipment for treating oilseeds have as yet been established in India on a commercial scale, and that in consequence, no working results are available to enable a comparison with other methods to be made, the immediate establishment in India of large factories for the extraction of oils from such materials by chemical means cannot be definitely recommended. Such factories have, however, been working

satisfactorily in Europe for a considerable time, and improvements are constantly being effected both in regard to the efficiency o operations and to the quality of the products. At first, only products suitable for technical purposes were turned out, but extracted oils are now being utilised for food purposes. As far as the writer is aware, the only factory working in India on a commercial scale for the extraction of oil from any oil bearing material is the Calcutta factory of the Indian Oil Products Ltd. which has for some years been extracting oil from bazaar oil cake, and disposing of the extracted meal to the tea gardens. The oil produced is mainly sold to soap-makers. Despite the fact that the plant is old and comparatively inefficient, the results from a financial point of view have always been very satisfactory.

The solvent used by the Calcutta factory is benzine, which being the cheapest solvent available, is also largely used in Europe Benzine or low boiling petroleum, however, is not a suitable solvent for the treatment of castor seed or castor cake. Benzol, which is a low boiling point coal tar spirit or light oil, is more expensive, but is on the whole a better solvent than benzine. Benzol and alcohol can both be used for the extraction of castor seed and castor cake, the oil from which is miscible with them in all proportions. Carbon bisulphide which was formerly the principal solvent is not now largely used. The non-inflamable chlorine derivatives, carbon tetrachloride and trichlor-ethylene, despite the risk which their employment involves, are finding extended use in England for the preparation of food oils.

Roughly speaking, the process of extraction consists in percolating the solvent though the ground material in order to dissolve out the oil content. The solvent mixture is afterwards subjected to distillation, the solvent being condensed, and used over again, while the oil is recovered and treated in various ways to eliminate all trace of the solvent. In recent plants the above process has been considerably modified, and various economies in heat transmission have been effected, but the principle of the operation remains the same.

The percolation may take place in single tanks or in a battery system; the latter system enables the solvent to be passed in succession through the different tanks, until it becomes fully saturated with oil. A considerable economy in distillation is thereby effected. The very best design and construction is necessary in equipments of this type, and such are supplied by British firms. Messrs. Geo. Scott & Son, Ltd., London, and other British manufacturers prepare solvent extraction plants which are far superior to the cheap German made plants, whose inefficiency, high working charges, and inferior products retarded for many years the development of this useful method of oil production.

The extraction method is, on the whole, unsuitable for the original treatment of oil bearing material, both, or even one product of which is to be used as a food, either for man or animals. When, therefore, as in the case of oilseeds like linseed, cotton seed, copra, groundnuts, etc., there is a large and unsatisfied demand for the resulting oil cakes, it is obviously unwise to turn a useful food product into a manure. On the other hand, in the case of rapeseed the cake from which is only in moderate demand, of castor seed the cake from which can only be utilised as manure, or of forest products, such as mowrah seed, the residue from which is useful only as a fuel, extraction may prove to be the most satisfactory method of dealing with such materials.

Care must, however, be taken to see that the process is without injurious effects on the oil produced. Extracted rape oil is said to be equal, if not superior, to that obtained from the treatment in hydraulic presses, while, on the other hand, castor oil is said to be injuriously affected by some solvents. There is little doubt, however, that, provided the technical difficulties can be successfully overcome, the extraction of oil cake intended for manurial purposes, as well as the combination of hydraulic and extraction apparatus for dealing with seeds the residue from which is only useful as manure, are well worth consideration.

The cost of an extraction equipment may be roughly estimated as being 50 per cent. higher than that of a hydraulic equipment of

the same daily or hourly capacity, while the working charges wi probably be in about the same proportion. Any advantage possesse by the extraction system over the hydraulic system is due t the greater yield of oil, *e.g.*, the residue resulting from extractio contains only about 2 or 3 per cent. of oil as compared with a average of 10 per cent. in the case of hydraulic press cakes Against this advantage has to be placed the inferiority of th oil product except for soap-making, and of the residue except fo manurial purposes. The greater risk from fire and of injur to workmen may also retard the development in India of this syste of oil production.

Selection of Machinery.

The figures of capital cost per ton-hourly crushing capacity which are given above, represent the approximate cost of oil mill machinery of the type in question sufficient to enable one ton of oil bearing material to be crushed every hour the mill works. In some cases the figures given are for material which requires to be pressed once only, and in some cases for material which requires to be twice pressed. Roughly speaking, except in the case of a rotary ghani outfit, the total cost of which, including housing power, etc., is about three times the cost of the actual machinery as given above, the total cost of any equipment will be about double the price quoted for the actual machinery. By utilising the figures given above, comparing the efficiencies of the various types as shewn by the oil content of the resulting cakes given in Chapter V as well as the working charges per ton of material, and ascertaining by reference to Chapter III the suitability or otherwise of the particular type for the treatment of the oil seed or oil seeds in question, intending purchasers should be able, without further outside assistance, to decide which type of plant is most likely to meet their requirements. While efficiency as measured by oil yield should be the first consideration, it need not necessarily be the only one, and care should be taken to see that the cost, both capital and recurring, of such extra efficiency is not higher than the value of the excess products which such extra efficiency might be expected to yield.

CHAPTER V.

Survey of Efficiency of Machinery.

In order to enable definite conclusions to be arrived at regarding the efficiency or otherwise of the various types of oil pressing machinery now employed within the Presidency limits, district officers and others were invited to supply samples of the various kinds of oil cakes produced in their districts, as well as information concerning the type of machinery employed in the production of such samples. No attempt was made to obtain samples produced under any particular set of conditions or calculated to give results conforming to any particular theory. The samples may, therefore, be considered to be fairly representative, and the results of their analyses may be confidently accepted as indicative of the results obtained under ordinary working conditions within the Presidency.

The samples examined comprised :—

(1) Hydraulic Press Cakes	.. 13 samples.
(2) Expeller Cakes	.. 9 ,,
(3) Rotary Ghani Cakes	.. 8 ,,
(4) Country Ghani Cakes	.. 30 ,,

Classified as above the average oil contents were as under :—

	Average oil content.
(1) Hydraulic Press Cakes	.. 10·54 per cent.
(2) Expeller Cakes	.. 11·33 ,,
(3) Rotary Ghani Cakes	.. 12·30 ,,
(4) Country Ghani Cakes	.. 11·40 ,,

The average oil content of all the 60 samples will be found to be 11·35 per cent. As compared with the figures quoted in Appendices IV and V this indicates a loss of approximately a ton of oil for every 100 tons of oil seeds treated within Presidency limits. The results, though shewing that the oil-cakes produced in the Bombay Presidency contain oil in excess of what is considered to be desirable, are less unsatisfactory than had been supposed. The best results by each of the above methods are more or less satisfactory and are equal

to European and American practice. Thus the lowest oil content for hydraulic press cake (castor) *viz.*, 5·9 per cent.; for expeller cake (rape seed) 9 per cent.; for rotary ghanis (castor) 9·8 per cent. and for country ghanis (safflower) 6·85 per cent. are all quite up to European standards. On the other hand the worst results for each method, *viz.*, 18 per cent. for hydraulic press cake (mowrah); 15·7 per cent. for expeller cake (linseed); 15·80 per cent. for rotary ghani cake (tilseed); and 19·51 per cent. for country ghani cake (cocoanut) are all more or less indicative of carelessness in working or of attempts to overtax the machinery, rather than of fundamental defects in the types of machinery employed. Machinery, whether indigenous or otherwise, capable of giving results such as the best recorded above, is worthy of attention, and instead of blaming indigenous machinery and methods for India's want of success in this line, and recommending owners of such plants to scrap them and to purchase complicated and expensive machinery of foreign manufacture, which according to the figures quoted above is capable under unfavourable conditions of yielding results almost if not quite as bad as the worst obtained by indigenous methods, it would be well if the engineering staff of the Industries Department and other Government agencies would carefully study the working of the rotary and country ghanis and find out just what conditions are necessary to enable the operators of such machines to obtain results equal to the best reported above, and what are the causes which at times lead to the production of unsatisfactory results such as are also recorded. Such an investigation should present little difficulty to intelligent engineers who might even be able to suggest improvements in construction which would enable even the best recorded results to be exceeded. Provided the Industries Department engineers are able to shew how improvements can be effected at little or no additional cost, they will find the indigenous oil industry only too willing to accept advice and follow their instructions, and if the oil yield by indigenous methods can be increased by even 1 per cent., the total gain to the Presidency will be nearly four lakhs of rupees per annum.

Small capitalists who are desirous of starting oil mills, and who have less than Rs. 50,000 to invest, or who do not wish to crush more

than 10 tons of seed daily, would be well advised to pu
indigenous rather than foreign machinery. By purchasing
machinery a manufacturer would be able to treat nearly six ti
much material in the same time for the same capital cost as he
if he purchased foreign machinery. For large capitalists wh
to go into the business on a more extensive scale, the selecti
the most suitable type of machinery is a more complicated m
Suffice it to say that the results tabulated above go to
that *hydraulic equipments* give satisfactory results with castor
(double pressing), linseed, cotton-seed and, apart from the qu
of the inferior quality of the resulting hot pressed oil, with groun
also. They ought to be equally suitable for the treatment of mo
seed, but neither of the samples of mowrah cake were found
satisfactory. *Expeller equipments* appear to give satisfactory r
in the case of copra, rapeseed, groundnut and safflower seed.
linseed they would appear to be less satisfactory. *Rotary g*
give good results with castor-seeds, tilseed and groundnuts
comparatively good results with copra; they ought to treat sat
torily all material which can be successfully treated in country gl
Country ghanis give excellent results with safflower, mustard
jamba seeds, and good results with niger-seed, copra, and ti
They do not appear to be equally efficient in dealing with gro
nuts, rapeseed and black mustard seed. The reason for th
not apparent, and it is suggested that this and other points w
have not been cleared up by the present enquiry should be in
gated further.

TABLE XII.

Oil content (Percentage) of samples of oil-cakes obtained under ordinary working conditions in the Bombay Presidency in 1920.

No.	District from which sample was obtained	Variety of oil-cake.	Botanical name of seed	Method of expression.	Analysed by		Oil content per cent.	Remarks.
					Designation or name.	Address.		
1	Bombay City ..	Linseed ..	(Linum Usitatissimum.)	Hydraulic Press.	The Chemical Analyser to Government, Bombay.	J. J. Hospital Byculla, Bombay.	10 per cent. ..	(Single Pressing.)
2	,, ..	Groundnut ..	(Arachis Hypogaea) ..	,,	,, ..	,, ..	9·80 per cent.	(Double Pressing.)
3	,, ..	Cocoanut ..	(Gossypium Herbacheum.)	Rotary ..	,,	,, ..	14·1 per cent.	
4	,, ..	Groundaut ..	(Arachis Hypogaea) ..	,, ..	A. J. Turner, Esq., Professor of Chemistry.	V. J. Technical Institute, Bombay.	13·00 per cent.	
5	,, ..	Linseed ..	(Linum Usitatissimum.)	Small Hydraulic Press.	,,	,, ..	8·32 per cent.	(Single Pressing.)
6	,, ..	Tilcake ..	(Sesamum Indicum) ..	Country ghani..	,, ..	,, ..	12 86 per cent.	
7	,, ..	Castor ..	(Ricinus Communis)..	Rotary ..	Assistant Controller (Oils & Paints).	Old Custom House, Bombay.	9 08 per cent.	
8	,, ..	,, ..	Do. ..	Country ghani.	,, ..	,, .	8 58 per cent.	Previously partially treated in rotary ghani.
9	,, ..	Groundnut ..	(Arachis Hypogaea) ..	Expeller ..	A. J. Turner, Esq. ..	V. J. Technical Institute.	9·96 per cent.	
10	,, ..	Sarsee ..	(Brassica Campestris)..	Country ghani.	,, ..	,, .	12·60 per cent.	
11	,, ..	Tilcake ..	(Sesamum Indicum) ..	,, ..	,, ..	,, ..	12·40 per cent.	
12	,, .	Groundnut ..	(Arachis Hypogaea) ..	Rotary ..	Agricultural Chemist to the Government of Bombay.	Poona ..	10·25 per cent.	
13	,, .	Cocoanut ..	(Cocos Nucifera) ..	,, ..	,, ..	,, ..	12·75 per cent.	
14	,, .	Tilcake ..	(Sesamum Indicum) ..	,, ..	,, ..	,, ..	15·80 per cent.	

Surat ..	Decorticated cotton seed.	(Gossypium Herbaceum.)	Hydraulic Press.	Dr. A. N. Meldrum, R. M. Science Institute.	Ahmedabad ..	12·20 per cent.	(Single Pressing.)
Sholapur ..	Kardi ..	(Carthamus Indicus) ..	Country ghani.	,, ..	,, ..	10·70 per cent.	
,, ..	Groundnut ..	(Arachis Hypogaea) ..	,, ..	,, ..	,, ..	12·40 per cent.	
Ahmedabad ..	Castor ..	(Ricinus Communis)..	Hydraulic Press.	Asst. Controller (Oils & Paints).	Bombay ..	9·2 per cent.	(Double pressing.)
Bijapur ..	Groundnut ..	(Arachis Hypogaea) ..	Expeller ..	Dr. A. N. Meldrum..	Ahmedabad ..	10·6 per cent.	Once pressed only, *i.e.*, rolled and then pressed.
,, ..	Linseed ..	(Linum Usitatissimum.)	,, ..	,, ..	,, ..	15 7 per cent.	
,, ..	Groundnut ..	(Arachis Hypogaea) ..	Rotary ghani ..	,, ..	,, ..	14·00 per cent.	
Bombay ..	Groundnut ..	Do ..	Hydraulic Press.	Chemical Analyser to Government.	Bombay ..	10·5 per cent.	(Single Pressing.)
,, ..	Castor ..	(Ricinus Communis)..	,, ..	Asst. Controller (Oils & Paints).	,, ..	11·7 per cent.	(Single Pressing.)
Godhra ..	Mowra ..	(Bassia Latifolia) ..	,, ..	Chemical Analyser to Government.	,, ..	18·00 per cent.	(Single pressing.)
Bijapur ..	Groundnut ..	(Arachis Hypogaea) ..	Expeller ..	A. J. Turner, Esq. ..	V. J. Technical Institute, Bombay.	9·10 per cent.	
,, ..	Kardi (decorticated).	(Carthamus Indicus)..	,, ..	,, ..	,, ..	10·29 per cent.	
,, ..	Linseed ..	(Linum Usitatissimum.)	,, ..	,, ..	,, ..	14·95 per cent.	
,, ..	Groundnut ..	(Arachis Hypogaea) ..	Country ghani ..	,, ..	,, ..	12·30 per cent.	
,, ..	Kardi ..	(Carthamus Indicus) ..	,, ..	,, ..	,, ..	12·98 per cent.	
Belgaum ..	Niger cake ..	(Guizotia Abyssinica) ..	,, ..	,, ..	,, ..	10·41 per cent.	
,, ..	Groundnut ..	(Arachis Hypogaea) ..	,, ..	Chemical Analyser ..	Bombay ..	12·80 per cent.	
,, ..	Safflower ..	(Carthamus Indicus) ..	,, ..	,, ..	,, ..	9·50 per cent.	
Karachi City ..	Jamba cake ..	(Eruca Sativa) ..	,, ..	,, ..	,, ..	7·50 per cent.	
,, ..	Cocoanut ..	(Cocos Nucifera) ..	Expeller ..	,, ..	,, ..	11·4 per cent.	
,, ..	Tilcake ..	(Sesamum Indicum) ..	Country ghani ..	..	,, ..	10·7 per cent.	
,, ..	Groundnut ..	(Arachis Hypogaea) ..	,, ..	,, ..	,, ..	13·1 per cent.	

No.	District from which sample was obtained.	Variety of oil-cake.	Botanical name of seed.	Method of expression.	Analysed by		Oil content per cent.	Remarks.
					Designation or name.	Address.		
37	Karachi City ..	Castor ..	(Ricinus Communis) ..	Country ghani..	Agricultural Chemist to Govt. of Bombay.	Poona ..	7·65 per cent.	
38	,, ..	Cocoanut ..	(Cocos Nucifera) ..	,, ..	,, ..	,, ..	10·70 per cent.	
39	,, ..	Sarreh (Black) ..	(Sinapis Nigra) ..	,, ..	,, ..	,, ..	11·55 per cent.	
40	,, ..	Mustard ..	(Sinapis Alba) ..	,, ..	,, ..	,, ..	7·30 per cent.	
41	Belgaum .	Safflower ..	(Carthamus Indicus) ..	,, ..	,, ..	,, ..	8·00 per cent.	
42	,, ..	,, ..	Do. ..	,, ..	,, ..	,, ..	6·85 per cent.	
43	,, ..	,, ..	Do. ..	,, ..	,, ..	,, ..	6·85 per cent.	
44	Satara ..	Groundnut (undecorticated).	(Arachis Hypogaea) ..	,, ..	Dr. A. N. Meldrum,..	Ahmedabad ..	15·8 per cent.	
45	,, ..	,, ..	Do. ..	,, ..	,, ..	,, ..	12·1 per cent.	
46	,, ..	,, ..	Do. ..	,, ..	,, ..	,, ..	12·1 per cent.	
47	,, ..	,, ..	Do. ..	,, ..	,, ..	,, ..	14·3 per cent.	
48	Ratnagiri ..	Tilcake ..	(Sesamum Indicum) ..	,, ..	A. J. Turner, Esq. ..	V. J. Technical Institute, Bombay.	10·77 per cent.	
49	,, ..	Groundnut ..	(Arachis Hypogaea) ..	,, ..	,, ..	,, ..	13·11 per cent.	
50	,, ..	Cocoanut ..	(Cocos Nucifera) ..	,, ..	,, ..	,, ..	19·51 per cent.	
51	Ahmedabad ..	Mowra ..	(Bassia Latifolia) ..	Hydraulic Press..	Chemical Analyser to Government.	Bombay ..	13·8 per cent.	(Single Pressing.)
52	,, ..	Rapeseed ..	(Brassica Campestris) ..	Expeller ..	,, ..	,, ..	9·0 per cent.	
53	,, ..	Linseed ..	(Linum Usitatissimum) .	,, ..	,, ..	,, ..	11·0 per cent.	
54	,, .	Castor .	(Ricinus Communis) ..	Country ghani ..	,, ..	,, ..	11·8 per cent.	
55	,, ..	Castor (undecorticated).	Do. ..	Hydraulic Press..	,, ..	,, ..	5·9 per cent.	(Double Pressing.)
56	,, ..	Castor (decorticated).	Do. ..	,, ..	,, ..	,, ..	6·9 per cent.	(Double Pressing.)
57	,, ..	Linseed ..	(Linum Usitatissimum)..	,, ..	Agricultural Chemist to Govt. of Bombay.	Poona ..	10·35 per cent.	
58	,, ..	Tilseed ..	(Sesamum Indicum) ..	Rotary ..	,, ..	,,	9·40 per cent.	
59	,, ..	,, ..	Do. ..	Country ghani ..	,, ..	,, ..	15·80 per cent.	
60	Ratnagiri	Groundnut ..	(Arachis Hypogaea) ..	Hydraulic Press..	,, ..	,, ..	10·35 per cent.	(Single Pressing.)

CHAPTER VI.

The Refining of Vegetable Oils.

The art of oil refining has long been looked upon as mysterious business, requiring for its successful practice the po: session of secret knowledge and exceptional skill. More recentl however, owing to the great developments of chemical scienc the changes involved in oil refining have come to be better and mor generally understood. Great improvements also, both in regar to methods and equipment, have been effected within recent years In spite, however, of all that has been written on the subject, o refining is still looked upon as being a complicated business whic had better be left to experts. The want of an adequate supply c such experts is considered by some to be responsible for the slo development of the Indian oil pressing industry, and for the inferio ity of much of the oil met with in the bazaars. While a knowledg of chemical science is of great value in dealing on a large scale wit some of the more complicated problems of oil refining, it is by n means essential, especially for dealing on a small scale with the o refining problems of India. In many cases, the early applicatio of commonsense methods would effect an enormous improvemen in existing conditions and obviate entirely the necessity for mor drastic chemical treatment. Especially is the application of com monsense methods necessary in regard to the treatment of oil bear ing material previous to and during the actual pressing operation so that the resulting oil product may require only the minimum c treatment to fit it for use or for storage. Neglect of the raw materia especially during the monsoon is responsible for much of the exces sive acidity of oils produced thereafter, while the improvement i the oil product which might be brought about by careful attention t the previous removal of all dirt, broken seeds, shells, etc., from th raw materials is not generally appreciated. Again the necessity fo strict cleanliness in all oil milling operations does not appear to b understood by most of those engaged in the industry. Piles of hal treated materials are allowed to lie fermenting for days on the floor of oil mills before being finally disposed of. The utilization c

press sludge, too, is often delayed until it begins to smell strongly, which means that hydrolysis has set in, and that the oil obtained from it, will be of inferior quality. Strict cleanliness and attention to details such as those mentioned above will, especially in the case of oils obtained by cold or nearly cold pressure, go far to obviate the necessity for drastic chemical or other treatment. All oils whether obtained by mechanical or chemical means are, however, more or less impure, and require some sort of treatment to fit them for use or for storage. Even when produced by cold pressure from fresh material and under the best conditions they contain moisture and mucilaginous material which, if not removed, will lead to hydrolysis, and decomposition of neutral glycerides. Most oils also contain more or less free fatty acids. These if not excessive will probably do no great harm, but if present in excess they may render the oil less useful for certain purposes. Every effort should be made to keep the percentage of acidity as low as possible. Oils obtained by hot pressure or from inferior raw material will usually be found to require much more drastic treatment, than oils obtained by cold pressure from fresh materials, while oil such as that obtained from cotton seed requires even more drastic treatment than other hot pressed oils before it can be made use of in any way.

It is proposed therefore to indicate shortly a few methods of treatment which have been found useful and are considered to be applicable to Indian conditions. They may be conveniently divided into three classes, (1) methods of treatment which can be carried out by ordinary workmen, (2) methods of treatment involving the use of simple and safe chemicals but calling for the exercise of more than average intelligence, (3) more drastic methods of treatment involving the use of chemicals and the employment of experts. Needless to say the methods included in class (3) should never be employed if those included in class (2) will suffice to give a satisfactory product, nor should those included in class (2) be employed if satisfactory results can be obtained by the purely physical methods included in class (1).

Simple Methods of Treatment.

Such methods are generally commercial adaptations of simple household practices. Every cookery book contains recipes for improving the flavour or keeping properties of fats and oils while every Indian is familiar with the method whereby butter, which will only keep a short time, is converted into ghee, which has been known to keep fresh for hundreds of years. In the methods under discussion, just as in the examples given above, the change is brought about by the judicious application of heat, followed by removal of the precipitated impurities. In the case of cold drawn oil prepared from fresh material in the proper way, no other treatment should be necessary, while even inferior oils would be improved by the treatment. Care however must be exercised in carrying out the details. If the quantity to be dealt with is small and the oil is to be boiled by direct heat, the operation should be carried out in a boiling pan built into a flue in such a way that the hottest gases strike the sides rather than the bottom of the boiling pan. The vegetable matter, on precipitation, will sink to the bottom, and if the hottest gases strike the bottom of the boiling pan, the vegetable matter may become charred and thus injuriously affect the flavour and colour of the oil. Again, the heating should be gradual and just a little more than sufficient to drive off all moisture. If considered necessary fresh addition of water may be made from time to time during the boiling operation. When free from moisture the oil should be allowed to cool and settle. Provided time is no object, the best results will be obtained by allowing the impurities to slowly settle out. If time does not allow, the oil, when cool, may be strained through a dry clean cloth.

On the larger scale, the operation can be carried out in steam jacketed tanks having a jacket all round the sides, but not on the bottom. The bottom should be conical or dish shaped. Some simple stirring arrangement should be provided as well as an open steam coil. Closed steam coils are however unnecessary, and only lead to carbonization of vegetable matter and consequent injury to the oil. The steam jacket should have two steam outlets, one a syphon pipe for retaining steam up to atmospheric pressure and

another connected to a steam trap for higher pressures. Except for the final heat, only steam at atmospheric pressure should be used. As on the large scale slow settlement of the precipitate is not practicable a filter press is necessary. Except that the filtering area is vastly increased and oil is forced through the cloths under pressure instead of flowing by gravity, the operation of filtering oil by means of a filter press is similar to that of straining it through a cloth, as is done on the small scale. Filter presses should be installed in every mill producing over 1 ton of oil every day. They can be prepared in any iron works at a much cheaper rate than they can be imported. A filter press, complete with pump, capable of filtering up to 5 tons per day, can be manufactured for less than Rs. 1,000. When using a filter press, great care should be taken to see that the cloths are kept clean: otherwise the oil may be injured rather than improved by being passed through them. The purely physical method detailed above is suitable for the treatment of tilseed, groundnut, kardi, rape, niger and in fact most cold drawn edible oils, also for linseed oil, rape oil and castor oil, whether hot or cold drawn. It is not, however, suitable for cold drawn cocoanut oil which would be injuriously affected by the treatment. The mucilaginous matter must, in this case, be removed before the moisture is dried off. This is accomplished by mixing with the oil some filtering powder such as fuller's earth, and passing the mixture through a filter. The oil is afterwards slowly dried as detailed above. On the large scale, this treatment is carried out in a vacuum still at a temperature considerably lower than the boiling point of water. On the smaller scale excess moisture may be removed by stirring finely ground dry salt into the oil after filtration and allowing the whole to settle for about 24 hours. This will in some cases obviate the necessity of applying any heat whatever. The simple methods of treatment detailed above would, if applied in the small oil mills of this Presidency, effect a very considerable improvement in the quality and appearance of the oils offered in the local bazaars.

Less Simple Methods of Treatment.

This class of treatment includes :—

(*a*) Treatment of oils the acidity of which is higher than is

(*b*) Treatment of oils the colour of which is higher than is considered desirable.

(*c*) Treatment of oils required for burning purposes.

Oil, the acidity of which is higher than is considered desirable, for example hot drawn oil prepared from material the cold drawn oil of which was considered satisfactory, or oil obtained from slightly inferior material, may be improved by treatment with sodium carbonate or washing soda and salt, prior to the usual heat and filtration treatment. The acidity of oil may be reduced by about 1 to 2 per cent. by stirring into the warm (but not hot) oil about 10 per cent. of a 10 per cent. solution of sodium carbonate and keeping the oil and solution in intimate contact for one or two hours, after which about 5 to 10 per cent. of a salt solution containing about 2 per cent. of salt is added, and the whole is boiled up until steam begins to escape. The solutions are then allowed to settle out and are afterwards run off. The oil is then given one or two washings with clean water to remove all trace of salt or soda, and is thereafter dried and filtered in the usual way. If air pumps are available drying operations may be carried out at a temperature of about 150° F. This method of drying is not admissible in the case of castor oil which is likely to be more or less oxidized in the process.

In the case of oils the colour of which is at fault, treatment consists in the careful removal of moisture, after which about 5 per cent. of fuller's earth is thoroughly stirred for about twenty minutes into the heated oil which is thereafter filtered as quickly as possible to prevent it acquiring an unpleasant odour and flavour. Other chemical methods of bleaching are not admissible in the case of edible oils and it is doubtful whether there is any necessity for bleaching oils for technical purposes in India.

Oils, such as castor and rape, which are required for burning purposes, must be completely freed from all vegetable matter which would be likely to char the wicks of the lamps in which they are used. They are therefore given a preliminary treatment with about 1 per cent. of a mixture of equal parts sulphuric acid and water in a wooden vessel. After the vegetable matter has become charred, the treated

oil is thoroughly washed with hot water, and afterwards dried, and filtered in the usual way. The above treatment cannot be applied to oils which are intended, or are likely to be used, as lubricants. Only oils of reasonably good quality can be successfully treated by the methods included in the first two classes, viz., those which can be carried out by ordinary workmen or with intelligent supervision. In the case of more acid oils and of oils like crude cotton seed oil, more drastic treatment is required, and such treatment can only be successfully given under expert supervision. In such cases the oil, after a laboratory experiment to determine the exact percentage of acid present and the quantity and strength of solution required for its neutralization, is treated in a proper refining tank, with a solution of caustic soda of the required strength and in the correct proportion. Such solution contains about 25 per cent. more caustic soda than is theoretically required to neutralize the acid present. The oil is stirred and slowly heated up to a maximum of about 120° F. when the soda soap formed should be ready to sink to the bottom, carrying with it the impurities and excess colouring matter. After settling and running off from the crude soap stock which can be converted into a useful soap, the clear oil is washed, dried and filtered in the usual way. The actual percentage of refining loss should not exceed twice the percentage of free fatty acid originally present in the crude oil.

Bleaching.

In the case of oils such as groundnut and tilseed the colour of oil after treatment as above should be sufficiently light, but in the case of cotton seed oil, especially from old seed, the colour of the oil will be considerably darker than the refined oil obtained from American seed. To obtain a paler oil, bleaching with fuller's earth may be resorted to. After the oil has been freed from moisture about 5 to 5 per cent. of fuller's earth is stirred in and mixed vigorously with the oil for about twenty minutes, after which the mixture is pumped through a filter press to remove the fuller's earth. Considerable variations from the above or standard practices may be and are often introduced into the operations of refining. Particulars of such variations may be found in various textbooks. Bleaching with ozone

may prove effective with certain oils but not with Indian cotton seed oil.

Deodorizing.

Where the retention of the characteristic flavour of an oil is not desired, as for example, when the oils are intended to be used for the manufacture of butter substitutes or for cooking fats or, as in the case of cotton seed oil, where it is desired to eliminate the unpleasant odour which makes itself felt when the oil is first heated to a temperature higher than the boiling point of water, oil treated as above is further treated in what is called a deodorizer. Oils intended to be treated in this way should be as nearly neutral as possible, as oils showing excess acidity cannot be satisfactorily treated. Deodorizers may be either of the atmospheric or vacuum type. In the former type the oil is subjected to the heat of both closed and open steam coils. The former should be sufficient to raise the temperature of the oil to the temperature of the steam, while the latter should be sufficient to maintain the oil in an exceedingly vigorous state of ebullition, thus enabling all unpleasant odours to escape into the atmosphere. Some oils can stand higher temperatures than others. Cotton seed oil, for example, requires to be treated 5 to 6 hours at over 300° F. Groundnut and tilseed oils can be deodorized in about 4 hours at about 270° F. to 280° F. Cocoanut oil should not be heated over 250° F. and it can be deodorized in two hours.

In the vacuum type of deodorizers, the oil is similarly treated, but at reduced temperatures and pressures, and, in consequence, there is less likelihood of damage to the oil. The extra cost of deodorizing oils amounts in some cases to about Rs. 80 per ton of oil.

Hydrogenation.

This is one of the most recent improvements in oil treatment. By treating a liquid oil with hydrogen gas in the presence of a catalyst and at a certain definite temperature and pressure, liquid oils such as groundnut or cotton seed can be converted into solid fats like ghee or tallow. The equipment required is, however, very complicated and rather expensive. In view of the fact that supplies of material

capable of yielding solid vegetable fats are available in this Presidency and are not yet utilized, it is questionable whether there is any immediate necessity for the establishment of such plants in this Presidency at least for the production of soap and candle material. The demand, however, for a cheap and wholesome ghee substitute may yet lead to their establishment. It has been suggested also that, in the case of sesame oil, it might be possible to create an export trade in hydrogenated sesame oil, instead of exporting the more liquid oil.

Stearine Manufacture.

In America, before the advent of the hydrogenation process, considerable quantities of cotton seed stearine were prepared by refrigerating cotton seed oil and keeping it at temperatures of between 30° F. and 40° F. until the stearine settled out from the olein which was run off and sold as winter cotton seed oil. The stearine was afterwards pressed in hydraulic presses to free it from the remaining oil and to raise its melting point. Even in America the manufacture of cotton seed stearine is declining, and there is little prospects of its manufacture on a large scale in India. The percentage of stearine which would remain solid at summer temperature, obtainable from Indian cotton seed oil, is very small and the colour of the product is higher than is desirable in a ghee substitute.

Cocoanut oil, however, when similarly treated yields a harder and white stearine in a larger proportion and at a cheaper rate. As very low temperatures are not required to be employed, working expenses are much lower. Cocoanut stearine can be prepared either in large or small quantities and the plant required is simple and comparatively inexpensive. In this it differs greatly from the hydrogenation process of solid fat production which can only be successfully worked on a large scale. It is probable that the demand for a wholesome vegetable ghee substitute may in time lead to the establishment of this industry at least on a small scale.

CHAPTER VII.

Possible Local Outlets for the Products of an expanded Oil Industry.

It has already been shewn that any considerable expansion of the industry will necessitate the establishment of an export trade in one or both of the main products. At the same time the possibilities also of the local markets should be investigated, as it is always much easier to build up a successful export trade on the foundation of a flourishing home business than to establish an export trade alone.

The products for which markets have to be found are :—

(*a*) Oils (edible and technical)

(*b*) Oil cakes (cattlefood and manure)

(*c*) By-products (minor).

Demand for Oil as Oil.

The demand for oil as oil in India is undoubtedly increasing. This particularly applies to edible oils which are being more largely used in place of ghee, the price of which has recently increased to such an extent as to place it entirely beyond the reach of the poor. The partial substitution of oil for ghee in the army ration is symptomatic of the change which is taking place all over India and more particularly in Southern India, and the total increased demand for oil must consequently be considerable. This demand will undoubtedly go on increasing. The expansion in the demand for technical oils has, however, been inconsiderable, with the exception of linseed oil, which has almost completely replaced the imported article, and of castor oil, the demand for which for lubricating purposes appears also to have increased considerably.

Other Outlets for Oil.

In addition to the increasing demand for oil as oil, increased utilization of oil in the undernoted industries is necessary to secure an internal market for the oil products of an expanded oil industry

Industries utilizing oils include :—

(1) Manufacture of soap.
(2) Manufacture of ghee and butter substitutes.
(3) Manufacture of paints and varnishes.
(4) Manufacture of candles.
(5) Manufacture of compound lubricants.

Manufacture of Soap.

Cheap soap is already largely manufactured in India. It is estimated that the quantity manufactured in the Bombay Presidency alone amounts to not less than 6,000 tons per annum, while the annual import of soap of all kinds amounts to over 8,000 tons. The soap manufactured locally is mostly inferior soap made down to a price rather than up to a standard. Most of it is cold process soap prepared from cocoanut oil, heavily filled with soda ash and salt, and containing an excessive amount of water. The total fatty acid content of this type of soap is under rather than over 30 per cent. It sells, however, readily at a price considerably lower than that of imported soap. Unless the price of imported soap rises still higher, it is doubtful whether any considerable expansion of the manufacture of such soap can be expected. A good soap containing between 60 and 70 per cent. of fatty acids would, if offered at a price lower than the price of imported soap, find a ready market. It is doubtful whether such a soap could be profitably manufactured in India from marketable oils and fats, but there is no reason why it should not be possible to produce a high grade soap from the refining residues which are likely to result from the activities of an expanded oil industry. Cotton seed refining residue, for example if purified by repeated washing with caustic soda, and stiffened by the addition of a small proportion of mowrah oil makes an excellent brown carbolic or other soap at a very reasonable price.

Imported Household Soaps.

The imported soap business, particularly that of household soap, is largely in the hands of one or two big English manufacturers.

Their bar soaps are not of particularly high grade as far as Europe standards are concerned. They correspond roughly to what a called fifty per cent fatty acid soaps, and consequently contain mo water, and are more wasteful in use, than would be considered a visable in Europe. They are, however, regular in quality and a certainly more satisfactory in use than locally made soaps. As th apparently satisfy the present demand, the advisability of manufa turing a similar article in India would appear to be worth considerin The capture of any considerable portion of the imported soa business would require, however, strong financial backing.

Locally Made Toilet Soaps.

The toilet soap manufactured in the Bombay Presidency mostly of inferior quality. It contains too much free alkali an unsaponified fat ; it keeps badly and is wasteful in use.

Imported Toilet Soaps.

Imported soaps of good quality, sell at very high prices. A the toilet soap business, unlike that of household soap, is not a monc poly of one or two firms there appears to be no reason why well made and attractively scented and packed local product shoul not find a ready market at profitable rates.

Glycerine.

Prospective Indian manufacturers are repeatedly warned tha only by extracting all the glycerine, which is set free in the proces of soap manufacture, can they hope to compete with European manu facturers. Looking, however, to the present market rates for gly cerine, it does not appear that this article more than pays the cost o its recovery even in England, while in India, with hydrochloric aci at its present price, the cost of recovery would be prohibitive. Unless therefore, the market rate of glycerine advances, or that of hydro chloric acid declines, glycerine recovery in India will not pay.

Butter and Ghee Substitutes.

The import of ghee into the Bombay Presidency exceeds th export therefrom by about 8,000 ·

ee in the Bombay Presidency is also considerable, and if the ımption per head in the mofussil is only half as much as the ımption per head in Bombay City, the total consumption of 'residency cannot be far short of 50,000 tons per annum. It ɔeen pointed out, however, that a gradual substitution of oil hee has been going on for some time on account of the advanc- ɔrice of ghee. Sweet oils such as groundnut, cotton seed, til kardi, etc., are being used to a greater extent for culinary pur- s, and except in wealthy households the more expensive ghee ainly reserved foı special occasions, eating with cooked dishes ɔr use in the preparation of confectionery. It is doubtful :her consumers will knowingly pay for a ghee substitute, intend- ɔr general cooking purposes only, a price much in excess of the e they have to pay for sweet oils, and judging by the grade il which satisfies this demand, questions of quality count for ɜ. To have any chance of successful introduction as ghee sub- ıtes, such preparations must behave exactly like ghee when .ed and recooled, and as far as possible should resemble ghee in ur, odour, and flavour so that they can be used for eating with ɛed dishes, etc. No merely hardened oil product would have chance of permanent success, though it might be purchased fraudulent dealers for adulterating ghee. Even granted success ɔroducing an article closely resembling ghee, a great deal of pagandist work would be necessary before it could be successfully keted as a ghee substitute in the Bombay Presidency. The best r to test the correctness or otherwise of these conclusions or prospective manufacturers to import from Europe a few ship- nts of different hardened oils, and to attempt their sale as ghee stitutes in the markets of the Presidency.

It is doubtful also if there is any possibility of creating a demand :he Bombay Presidency for an article resembling margarine such is so largely manufactured and consumed in Europe. Butter is y used by a very small minority of the population, and that minority nore or less able and willing to pay the present or even a higher ɔe for genuine butter of good quality.

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Paints and Varnish Manufacture.

The only Indian oil, the demand for which is likely expand for industrial purposes, is linseed oil which is either raw or boiled for mixing with paints, or as the c vehicle in varnishes. Before the war, and before oil of local m facture came upon the market in any considerable quantities, annual import of linseed oil into Bombay and Karachi amou to about 1,600 tons, while the quantity contained in the mi paints imported probably amounted to between 300 and 400 t per annum. The Presidency's total requirements of linseed oil mixing with paints was therefore under rather than over 2,000 t a year. As has been pointed out in another chapter, locally prepa oil has to a large extent replaced the imported oil. There is, ho ever, considerable room for improvement in the quality of many the locally produced "boiled oils." Many of them are insu ciently boiled, dry most unsatisfactorily and when thinly spread glass yield an irregular and patchy film. Only one firm in t Bombay Presidency appears to have succeeded in making a boil oil which complies with all the requirements of the Governme specification for that article. Unless, therefore, improvemen in its manufacture are effected, purchasers of boiled oil may possib revert to the use of imported oils, rather than run the risk of havir inferior locally prepared oils foisted on them.

The establishment of paint factories to supply the needs of th Presidency would only increase the demand for linseed oil by abou 300 tons per annum. As however such factories, if run on prope lines, would be almost certain to develop business with other pro vinces there is every possibility that they may require very much large supplies of oil. At the present moment scarcely any of the smal paint factories in the Bombay Presidency prepare satisfactory paint Their equipment is very crude, and incapable of thoroughly grinding the stiff paste. In consequence of this the paints produced are gritty and their opacity and spreading capacity are seriously affected. Better paint grinding machinery must be imported and installed in Bombay factories before they will be able to compete with the paint [illegible] of D

ories, also, should be on a large enough scale to warrant the oyment of a practical paint maker, preferably one trained in pe. Theoretical knowledge is very useful in its way, but even important is the practical knowledge which comes from long rience in a well equipped paint works.

Varnish Making.

Varnish, and that of rather poor quality, has hitherto been made in small quantities on this side of India. Every technical ist thinks he can make varnish and many of them set out to ufacture it on a commercial scale, but they soon find that also, practical experience is of equal if not greater import- than chemical lore. Again, difficulty is experienced in regard e ageing of the varnish. Financial restrictions prevent the ge of good varnish in large quantities for a sufficiently long so that small factories generally end by manufacturing the cheapest substitute for copal varnishes, or take up some line altogether. For the manufacture of satisfactory varnishes investment of a considerable amount of capital is necessary. ufacturers must also be prepared to provide free trial samples o spend money fairly lavishly in convincing likely purchasers ucts. Having secured a market, they details of manufacture and see that the maintained. Varnish making ly developed by inexperienc- or by versatile amateurs.

...anufacture of oil cloth appears to offer some scope for zation of at least a small portion of the linseed oil supplies, would become available in the event of any considerable expan- the oil industry. The annual imports of this article into before the war amounted to over 800,000 square yards at over Rs. 5,25,000. As far as the writer is aware, there o oil cloth factories in India, and such a factory, if established proper basis with up-to-date equipment, and with proper tech- assistance, would appear to be capable of yielding satisfactory s and afford good prospects of further development.

Manufacture of Candles.

The imports of candles into the Bombay Presidency in p years amounted to approximately 1,100 tons per annum. The part came, as might be expected, from Burmah. Assumir the 900 tons of Burmese origin contained an average of 15 per cent. of stearic acid, the total quantity of an oil such as rah required to supply the stearic acid portion would be n than 400 tons per annum, while to supply the stearic acid con in candles imported from England in pre-war years would f necessitate the hydrolysis of about 300 tons of a similar oil. local manufacture of candles probably does not exceed 200 to annum, and as these contain a very high proportion of acid, they should, if properly made and marketed, realise a . price than the mineral candle imported from Burmah. As a ı of fact, however, it is difficult to sell the almost pure st candles, even at the same rate as is obtained for the ı pure mineral wax candles. Owing to the fact that the de for glycerine has seriously declined, and that mowrah oil only about 30 to 35 per cent. of stearic acid suitable for ı making, the balance, *viz.*, oleic acid having to be u for the manufacture of soap, it is doubtful whether there is an mediate opening for further expansion in this line.

At the same time there appears to be no reason why the ness of preparing stearic acid for candle manufacture shoul prove profitable in this Presidency. In pre-war years Bı imported, chiefly from Belgium, nearly 1,000 tons of steari per annum. Doubtless this and other markets could be expl and in time a profitable addition to the Presidency's export might be effected. The matter is, at any rate, well worth the sideration of persons interested in the development of the products of the Presidency.

Compound Lubricants.

For lubricating certain kinds of machinery, notably n engines, and high class motor car engines, compound lubr

Manufacture of Candles.

The imports of candles into the Bombay Presidency in pre- years amounted to approximately 1,100 tons per annum. The gre part came, as might be expected, from Burmah. Assuming t the 900 tons of Burmese origin contained an average of ab 15 per cent. of stearic acid, the total quantity of an oil such as m rah required to supply the stearic acid portion would be not than 400 tons per annum, while to supply the stearic acid contai in candles imported from England in pre-war years would furt necessitate the hydrolysis of about 300 tons of a similar oil. local manufacture of candles probably does not exceed 200 tons annum, and as these contain a very high proportion of ste acid, they should, if properly made and marketed, realise a hig price than the mineral candle imported from Burmah. As a ma of fact, however, it is difficult to sell the almost pure stear candles, even at the same rate as is obtained for the alm pure mineral wax candles. Owing to the fact that the dem for glycerine has seriously declined, and that mowrah oil yie only about 30 to 35 per cent. of stearic acid suitable for can making, the balance, *viz.*, oleic acid having to be utili for the manufacture of soap, it is doubtful whether there is any i mediate opening for further expansion in this line.

At the same time there appears to be no reason why the bu ness of preparing stearic acid for candle manufacture should prove profitable in this Presidency. In pre-war years Burn imported, chiefly from Belgium, nearly 1,000 tons of stearic a per annum. Doubtless this and other markets could be exploit and in time a profitable addition to the Presidency's export tr might be effected. The matter is, at any rate, well worth the c sideration of persons interested in the development of the fo products of the Presidency.

Compound Lubricants.

For lubricating certain kinds of machinery, notably mai engines, and high class motor car engines, compound lubrica

are preferred to lubricants prepared exclusively from either vegetable or mineral oils. Castor and rape oils, the latter after being air blown to increase its viscosity and lessen its tendency to gum, are compounded with varying proportions of mineral oil of a suitable grade, and used for lubricating purposes. As one large American lubricating oil concern utilises in its compound lubricant manufacture about 4,000 tons of rape oil every year, the total quantity of this oil utilised in Europe and elsewhere must be very large. Again, for high class aeroplane engines, the most popular lubricant at present is a compound consisting chiefly of castor oil.

Quite recently it has been discovered that the addition of 2 per cent. of free fatty acids to a mineral oil increases its lubricating properties to the same extent as would be effected by the addition of 80 per cent. of a neutral vegetable oil such as rape. Not only should the results of this discovery effect a very considerable economy in the use of vegetable oils, but owing to the small extra cost of such an addition, it is possible that in the near future the business of manufacturing this class of lubricant will greatly expand. The whole question of the manufacture of compound lubricants is well worth the attention of prospective industrialists and the establishment of such an industry in India would provide an outlet for a fairly large quantity of oil.

Oil Cakes.

Only about 10 per cent. of the oil cake produced in India is exported. The same is the case as regards the Bombay Presidency. The balance in this Presidency is utilised chiefly for cattle feeding and for manurial purposes. A small proportion is utilized as fuel. The local demand appears to be more than satisfied and failing a radical change in the agricultural methods of the Presidency there seems to be little hope of creating an increased demand sufficient to take up any considerable proportion of the increased output which will result from an expansion of the oil pressing industry. Nor is this because of the high prices asked by manufacturers for their product. During the war, when freight to Europe was unobtainable, best mill pressed linseed cake for which English farmers are now willing to pay nearly £7.5 per ton. failed to find

buyers, even at Rs. 30 per ton, and had to be disposed of in Bombay for fuel purposes in some of the local mills.

Assuming that the total weight of oil cake utilised within the Presidency limits is approximately 75,000 tons per annum, of which approximately half is used for cattle feeding and half as manure, the quantity utilised locally appears remarkably small when it is compared with the British demand of approximately 1,300,000 tons per year.

Use of Oil Cake for Cattle Feeding.

As far as the use of oil cakes for cattle feeding is concerned, one of the chief reasons for the small consumption of oil cakes is the fact that in India there is no shortage of concentrated foodstuffs such as is experienced in Europe. Pulses, such as gram and guvar are largely grown and utilised within Presidency limits, while refractions from edible pulses, such as chuni are available in considerable quantities. But the greatest competitor of the oil cakes is cotton seed, and a comparison of the local consumption of this seed during the years 1913-14 and 1916-17, *i.e.*, two years of normal rainfall, goes to shew that its use is increasing. The figures are as under :—

TABLE XIII.

Apparent local consumption of cotton seed in the Bombay Presidency limits in the fiscal years 1913-14 *and* 1916-17.

	1913-14.		1916-17.	
	Total tons.	Total tons.	Total tons.	Total tons.
Yield of local crop ..		300,000 approx.		300,000
Inland imports into Presidency.	342,000		71,000	
Inland exports from Presidency.	165,000		49,000	
Total excess of imports over exports.		177,000		22,000
Total available for use and seaborne export.		477,000		322,000
Actual seaborne export ..		270,000		37,000
Apparent local consumption for planting and cattle feed-		207,000		285,000

Later figures are not available, but it does not appear likely that reaction against the use of cotton seed for feeding purposes has set in. Assuming that approximately 27,000 tons are required planting purposes, the quantity utilised as cattle food within the sidency in 1916-17 was not far short of 260,000 tons. Almost only hope of increasing the local demand for edible oil cakes in Bombay Presidency lies in the possibility of convincing the ivating community of the desirability of substituting such cakes the whole cotton seed which they now feed to their cattle. nsiderable amount of propagandist work in this line has already n undertaken principally by interested parties, and the results leduced from the figures given above, have been decidedly ppointing. If the cultivators are to be convinced of the tefulness of their present practice, this can only be accomplished the wide publication of the results of successful experiments ied out by the Agricultural Department. Such tests should carried out under different conditions, and for fairly long ods. They should be carried out with a view, not only to rtain the effects of different foods on the milk or work output of nals undergoing the trials, but also to find out the effect of the erent foodstuffs on the animals themselves. The effects of plying foodstuffs containing greater and smaller percentage of should be carefully investigated, and the digestibility of the more rations should be ascertained by careful analysis of the excre- it of the animals undergoing the tests. So many unproved ements have been made regarding the indigestibility of the oil tent of cattle rations containing an excess of this constituent, that necessary once and for all to prove whether or not the excrement cattle fed on cotton seed and locally prepared oil cakes, really s shew an excess of oil. Should the results of the trials go to w that oil cakes and cotton seed are interchangeable in cattle ons, tables should be prepared shewing the parity at which it uld pay the cultivators in any part of the Presidency to substitute of the oil cakes for the cotton seed, which they are now using. s doubtful whether any good will result from attempts to persuade ivators to use a greater amount of oil cakes for feeding their

cattle rather than to use them as manure for their crops. Owing the widespread use of cowdung as fuel only a very small proport of the manurial elements of the foodstuffs given to cattle find tl way to the cultivated areas. Until some substitute fuel beco available the use of cattle dung for this purpose will contin and the comparison of the values of such foodstuffs must be confi to their immediate effect on the animals themselves either in reg to milk and work, or to physical condition. The absence in In of any substitute for the great animal fattening industries of West no doubt partly accounts for India's low consumption of c centrates including oil cakes, and it is doubtful whether it is e desirable that such industries should be introduced into a coun like India.

Use of Oil Cakes as Manure.

It is doubtful whether there is much scope within this Pre dency for the extended use of oil cakes as manure. At present all t castor cake produced within the Presidency is so utilised, while the Deccan considerable quantities of safflower and niger cakes a also used for manuring sugarcane. Other edible oil cakes a not used to any considerable extent, chiefly because of the fact tl their presence in the soil attracts the attention of pigs and other w animals, and leads to the destruction of the young cane sets. seems possible that this difficulty could be overcome by adding such ground oil cakes a proportion of the powder of poor but inedil cakes such as mowrah and karanj. Except in regard to sugarcar the cultivation of which offers scope for expansion, and garden cro which require the addition of a quick acting nitrogenous manu there does not seem to be much room for the extended use of oil cak as manure. As a matter of fact, with the aforementioned exceptio few of the large Indian crops appear to benefit greatly from the lavi use of nitrogenous fertilizers such as oil cakes.

Minor By-products of the Oil Industry.

The only minor by-products of any considerable importan are those connected with the cotton seed industry and with tl refining residues from other oils. The latter can be convenient

nto soaps while of the former, the short cotton or lint, recovery is found to be profitable, can be used for the e of bedding, in upholstery, and possibly in paper making. residue, after repeated treatment with caustic soda and vith an oil of higher melting point, can be used for the of cheap and effective household soaps. It is doubtful ndia it will be worth while carrying the treatment further, rica the residue is acidified to effect the separation of the which are afterwards distilled leaving behind a pitch ch is used for the manufacture of paints, roofing felts, etc. d fatty acids are used directly or after removal of stearic cing higher grade soaps. For the husks removed in the preparing decorticated cotton seed cake there is, within ncy, an almost insatiable demand for feeding to milking ey are nutritious, stimulate the secretion of milk, and ary bulk to the milking time ration which is such a eature of Indian dairy practice.

Human Food Products from Oil-cakes.

ssibility of obtaining from the comparatively inexpensive od products of high grade suitable for the preparation of , etc., for human consumption has for long occupied the chemists, dietists and economists. The results obtained whole been rather disappointing. In America, consider- ess has been made in the preparation of an edible flour seed cake which, when mixed with wheat flour in certain , can be used for the preparation of nourishing bread and cakes. In this Presidency the efforts of the Industries t to encourage the preparation and use of a similar flour dnut cakes has so far yielded no practical results. Both and India, the chief difficulty has been to prepare a flour able keeping properties. When freshly prepared, cotton s pleasant in appearance, of good odour and most pala- er being stored for some time, even in America, it goes off odour and taste and can only be used as cattle food or n India, owing to the higher temperatures and in some easons, excessive humidity, cotton seed flour is much less

p into soaps while of the former, the short cotton or lint, its recovery is found to be profitable, can be used for the ıre of bedding, in upholstery, and possibly in paper making. ng residue, after repeated treatment with caustic soda and with an oil of higher melting point, can be used for the ɔn of cheap and effective household soaps. It is doubtful ı India it will be worth while carrying the treatment further, ıerica the residue is acidified to effect the separation of the s which are afterwards distilled leaving behind a pitch hich is used for the manufacture of paints, roofing felts, etc. led fatty acids are used directly or after removal of stearic ıaking higher grade soaps. For the husks removed in the ɔf preparing decorticated cotton seed cake there is, within lency, an almost insatiable demand for feeding to milking They are nutritious, stimulate the secretion of milk, and ɛssary bulk to the milking time ration which is such a ɛ feature of Indian dairy practice.

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rked up into soaps while of the former, the short cotton or lint, ›vided its recovery is found to be profitable, can be used for the ınufacture of bedding, in upholstery, and possibly in paper making. ıe refining residue, after repeated treatment with caustic soda and ffening with an oil of higher melting point, can be used for the :paration of cheap and effective household soaps. It is doubtful ether in India it will be worth while carrying the treatment further, t in America the residue is acidified to effect the separation of the ty acids which are afterwards distilled leaving behind a pitch idue which is used for the manufacture of paints, roofing felts, etc. ıe distilled fatty acids are used directly or after removal of stearic d for making higher grade soaps. For the husks removed in the ›cess of preparing decorticated cotton seed cake there is, within : Presidency, an almost insatiable demand for feeding to milking ck. They are nutritious, stimulate the secretion of milk, and ·e necessary bulk to the milking time ration which is such a ticeable feature of Indian dairy practice.

Human Food Products from Oil-cakes.

The possibility of obtaining from the comparatively inexpensive -cakes, food products of high grade suitable for the preparation of :ad, cakes, etc., for human consumption has for long occupied the ention of chemists, dietists and economists. The results obtained ve on the whole been rather disappointing. In America, consider- e progress has been made in the preparation of an edible flour m cotton seed cake which, when mixed with wheat flour in certain ›portions, can be used for the preparation of nourishing bread and ıthsome cakes. In this Presidency the efforts of the Industries partment to encourage the preparation and use of a similar flour m groundnut cakes has so far yielded no practical results. Both America and India, the chief difficulty has been to prepare a flour :h reasonable keeping properties. When freshly prepared, cotton :d flour is pleasant in appearance, of good odour and most pala- ›le. After being stored for some time, even in America, it goes off colour, odour and taste and can only be used as cattle food or nure. In India, owing to the higher temperatures and in some ·ts and seasons, excessive humidity, cotton seed flour is much less

stable than it is in America, and it soon goes mouldy. Biscuits and other preparations in which cotton seed flour has been used have also inferior keeping properties as compared with similar products prepared from wheat flour. As cotton seed, the cake from which will be suitable for the preparation of cotton seed flour, is only obtainable for two or three months after harvest, extensive experiments are necessary to find out some method, either of treatment or packing, which will eliminate this excessive "tenderness" and enable the flour to remain fresh even after several months' storage. At the same time the cost of such treatment or container must be low enough to enable the resulting product to complete with the flour of pulses such as chana dal. Another difficulty experienced even with freshly prepared flour is the fact that preparations in which it is used darken badly while being cooked. This appears to be due to caramelization of the sugar, etc., present. In America, this difficulty is to a certain extent overcome by cooking with steam rather than dry heat, but in India there is, except in the preparation of boiled rice, very little steam cooking. It must be clearly understood that cotton seed flour does not or should not consist merely of the siftings from ground cake. Such a product, if examined under the microscope, would be found to consist of small cubical particles, while a true flour should consist of minute flat flakes. Until the difficulties detailed above have been overcome, there is little prospect of the manufacture of cotton seed flour in India becoming an important or profitable business. It is probable that the situation as regards the manufacture of nutramine from groundnuts is similar to that detailed above, and that a considerable amount of experimental work is necessary before such a preparation can be confidently marketed.

CHAPTER VIII.

The Development of an Export Trade in the Products of an expanded Oil Industry.

It is clear, from the conclusions arrived at in the foregoi chapters, that the development of an export trade in the products an expanded industry is a necessity. Facilities for such must fact be provided before any considerable expansion can take pla The only products which it will be necessary to export are oil cak and oil.

Oil Cakes Export.

The oil cakes for which there is in Europe an almost insatiat demand are linseed cake, and cotton seed cake. There is a con derable demand for groundnut and cocoanut cakes, but for oth kinds of oil cake the demand in normal times is poor. As all the cakes are sold on an analytical basis, and Indian exporters are n always satisfied that they are fairly treated when their cases are su jected to arbitration, it might be an advantage if representativ of the Indian Trade Commissioner were appointed at the princip ports to look after the interests of Indian exporters.

Oil Exports.

The establishment of a successful export trade in oils will l a much more difficult matter. Not only is the product a con paratively expensive one and one liable to losses on the voyage, b the business also is new and there is no insatiable demand for tl article. There is, in fact, a decided preference for the raw materi which in many European countries takes the form of the impositic of heavy import duties on the finished product.

Necessary Conditions.

The first essential requirement is a considerable improveme in the quality of the oil produced within the Presidency. At tl present time it is doubtful if more than forty per cent. of the produ is even of second grade, *i.e.*, when judged by European standard A very much smaller percentage might pass for first quality, and tl balance, equal to nearly half the production would in Europe l classed as off oil and be disposed of accordingly

Standardization.

ith the exception of refined cotton seed oil the acidity of which not exceed $\frac{1}{8}$th per cent., most oils shewing under 2 per acidity would be classed as first grade ; oils shewing between 2 per cent. might be considered to be second grade ; and all ewing over this percentage should be classed as third grade or . Every effort should be made to increase the proportion of d second grade oils and to eliminate, as far as possible, oils of quality. How this might be accomplished has been shewn pter VI. In no case should the export of oils of the third y be encouraged.

Government Standardization.

ıreful analysis and classification of all oils intended for export : necessary, and as proper arrangements for carrying out the ıry tests could not be provided except by large manufacturers, ; even their results would be more or less suspect, it is ted that, for the development of the oil crushing industry of esidency, Government should establish test houses, through rehouses of which, all oils for export would require to pass obtaining the Government grade marks. Oils might be graded vn above and special seals marked " First Grade " or " Second " as the case may be, might be attached to all packages the ts of which were found to be in accordance with the specified ements of either of these grades. No grade mark should be to packages containing oil of lower grades, nor should their from Government warehouses be allowed. The export of earing Government grade marks except from Government ouses should be prohibited, but no restriction need be placed export of ungraded oil. If particulars of the system of grading d were widely published in England and elsewhere, it is sug- that European importers would find it to their advantage ınge for supplies of such oils, instead of purchasing ungraded uncertain quality. Bombay and Karachi commercial firms also be safeguarded against possible claims for variations in , and would be willing to buy and sell graded oils on reasonable For example if they have an enquiry for 100 tons Bombay

No. 2 grade linseed oil, they would contract with a bazaar or mofussil merchant to deliver that quantity to the Government Test Warehouse. Should the oil pass the necessary test the merchant would receive payment; if not, he would be forced to take back his oil. The officials in charge of such test warehouse would be kept up to the mark by the fear of different results being obtained on receipt of the oil in Europe, while their interests should be watched over by representatives of the Indian Trade Commissioner at the principal ports. A charge for inspection sufficient to defray at least a portion of the necessary expense should be imposed and be made payable in cash or stamp at the time of affixing the grade seals. It is suggested that the commercial and manufacturing communities concerned should be consulted as to the advisability of establishing such a system.

Containers.

This is a most important problem on the successful solution of which the success of an oil export trade will ultimately depend. It is largely on account of the high cost and comparative unreliability of available oil containers that the export of oil seeds has hitherto flourished and that of oils failed. The greater part of cotton seed oil exported from the United States to Europe and elsewhere is shipped in new oakwood barrels the insides of which have been coated with glue, paraffin wax, shellac, or silicate of soda, and the results appear to be fairly satisfactory. In this case, however, the oil does not leave the temperate zone or pass through countries the temperature and humidity of which shew any considerable variation so that the containers are not subjected to variations likely to lead to serious deterioration. Further, the shipments of such oil being usually of considerable magnitude, difficulty is not experienced with regard to their stowage alongside other merchandise which might be spoiled by leakage of oil. Indian exports, on the other hand, have to pass from the tropical to the temperate zone, and to withstand the adverse effects of considerable variations both of temperature and humidity. It is not clear whether leakage of oil is greater in the case of changes from lower to higher, or from higher to lower temperatures. Judging, however, by the greater leakage

which occurs in Indian oil godowns in the cold weather due to the shrinkage of the staves, it would appear to be greater in the case of the latter. In India, at any rate, the wooden barrel is not a very satisfactory package. This is due to the fact that in dry weather the natural moisture of the wood is evaporated, and as its place is not as quickly filled by the oil, greater expansion and contraction takes place than in the temperate zone. It is possible that the leakage from such causes might not be sufficient to warrant higher expenditure on other forms of containers, but for a long time to come full cargoes of oils will not be offered, and consequently fear of damage to other goods placed in the same holds, will lead to the rejection of oil shipments which shew the slightest tendency to leak. It is necessary, therefore, to look around for some form of package which will meet the requirements of carriers and reduce the possibility of loss through leakage. The familiar kerosene case containing two 4 gallon tins is not suitable as the loss from leakage in the event of rough handling is greater than in the case of wooden barrels. Large steel barrels are excellent containers but with freights at their present height the cost of returning empty barrels would be a very expensive matter and it is doubtful if any suitable return load could be arranged. At any rate, return loads could only be arranged by large concerns. The same difficulties apply more or less in the case of tank steamers, although in this case the difficulties may in future be more easily overcome. For the present the only suitable container available in almost unlimited quantities is the small 4 or 5 gallon double turned over oil drum made from 24 or 22 gauge galvanized iron sheets which can be manufactured locally and does not require very heavy or elaborate machinery. If arrangements can be made for their disposal at a reasonable price in Europe they should prove only slightly more expensive than wooden barrels and the leakage difficulty would be largely overcome.

In conjunction with the proposed scheme for testing and grading of oils, it is suggested that an attempt should be made to standardize containers so that the advantages of grading seals will not be neutralised by the damage caused to other goods by leaky oil containers. No consignments the containers of which are unsuitable for ocean transport should be accepted for test by the Government Test Warehouses.

APPENDIX No. I.

Oil contents of the principal Indian oil seeds available in the Bombay Presidency.

Name.	Botanical name.	Oil content per cent.
Castor seed ..	Ricinus Communis ..	46·50
Copra ..	Cocos Nucifera ..	65·70
Cotton seed ..	Gossypium Herbaceum ..	16·19
Groundnuts ..	Arachis Hypogaea ..	44·50
Jamba seed ..	Eruca Sativa ..	32·35
Linseed ..	Linum Usitatissimum ..	42·44
Mustard ..	Sinapis Nigra ..	31·33
Mowrah ..	Bassia Latifolia ..	40·45
Niger seed ..	Guizotia Abyssinica ..	35·37
Poppy seed ..	Papaver Somniferum ..	45·50
Rape seed ..	Brassica Campestris ..	40·45
Safflower seed ..	Carthamus Indicus ..	30·32
Sesamum seed ..	Sesamum Indicum ..	45·55

Principal Manufacturers of Oil Mill Machinery and Plant for the treatment of Vegetable Oils.

	Names.	Addresses.	Local Agents.
		UNITED KINGDOM.	
1.	Messrs. A. F. Craig & Co., Ltd.	Paisley, Scotland.	
2.	,, Greenwood & Batley, Ltd.	Leeds	Messrs. Duncan Stratton & Co., Bombay.
3.	,, Robert Middleton & Co., Ltd.	Sheepscar, Leeds	Messrs. Macbeth Bros. & Co., Ltd., Bombay.
4.	,, Manlove Elliott & Co., Ltd.	Nottingham	Messrs. J. Fleming & Co., Bastion Rd., Bombay.
5.	,, Rose, Downs & Thompson, Ltd.	Hull (Hydraulic Pressing and Solvent Extraction Plant).	Messrs. Marshall Sons & Co., Ltd., Ballard Road, Bombay.
6.	,, George Scott & Co., Ltd.	Kingsway Home, Kingsway, London W. C. (Solvent Extraction Plant).	
7.	,, Scott & Sons, Ltd.	72, Oxford St. London, W. 1. (Solvent Extraction Plant).	
8.	Mr. Howard Lane	Ashford, Middlesex. (Hydrogenation Plant).	
9.	Messrs. Blair, Campbell & McLean, Ltd.	Govan, Glasgow (Hydrogenation Plant).	
10.	Messrs. L. H. Johnson & Co., Ltd.	Carpenter Road, (Filter Presses) Stratford, London, E.	

		United States of America.	
1.	Messrs. The American Machine and Manufacturing Co.	Greenville S. C. (Oil Mill Machinery).	
2.	Messrs. Barnard & Leas Mfg. Co. ..	Moline Ill : (Cotton seed Hull Packing Machinery).	
3.	Messrs. Baner Bros.	Springfield, Ohio. (Cotton seed Decorticating Machinery).	
4.	Messrs. Brecht Co.	St. Louis, Missouri (Oil Refining Plant),	
5.	Messrs. Buckeye Manufg. Co. ..	Dayton, Ohio (Oil Mill Machinery).	
6.	Messrs. The Buruss Engineering Co.	Atlanta, Georgia (Anderson Oil Expeller).	Y. G. Pandit, Bombay.
7.	Messrs. Cardwell Machinery Co. ..	Richmond Va. (Oil Mill Machinery).	Messrs. J. Fleming & Co., Bastion Rd., Bombay.
8.	Messrs. The Diamond Huller Co. ..	Winona, Minn. (Cotton seed Decorticators).	
9.	Messrs. The French Oil Mill Machinery Co.	Piqua, Ohio (Oil Mill Machinery).	
10.	Messrs. The Murray Company ..	Atlanta, Georgia (Cotton seed Oil Mill Machinery).	
11.	Messrs. Sprout Waldron & Co. ..	Muncy, Pen. (Cotton seed Decorticating & Grinding Machinery).	
		Holland.	
	Messrs. Frans Smulders ..	Utrecht, Holland. (Expellers & Oil Mill Machinery).	The Holland Bombay Trading Co., Ltd., Bombay.

		Title.	Publisher.
1.	Andes, Louis E. ..	"Vegetable Fats and Oils" ..	Scott Greenwood & Co.
2.	Do.	"Drying Oils, Boiled Oil and Solid and Liquid Driers.	Do.
3.	Archbutt & Deeley	"Lubrication & Lubricants" ..	C. Griffen & Co.
4.	Brodie, N.	"The Manufacture of Paint and Varnish in India."	The Superintendent, Government Printing, Calcutta, for Indian Munitions Board.
5.	Chalmers, T. W.	"Production & Treatment of Vegetable Oils."	Constable & Co.
6.	Ellis, Carlton B.	"Hydrogenation of Oils" ..	D. Van Nostrand, New York.
7.	Ennis, William D.	"Linseed oil and other seed oils" ..	Do.
8.	Fryer & Weston	"Oils Fats and Waxes" ..	Cambridge University Press.
9.	Holde & Mueller	"Examination of Hydrocarbon Oils."	John Urby & Son, New York.
10.	Hurst, Geo H.	"Lubricating Oils, Fats & Greases".	Scott Greenwood & Co.
11.	Do.	"Soaps"	Do.
12.		"Industrial Handbook 1919" ..	Indian Munitions Board.
13.		"International Library of Technology Sections 36 to 44".	I. C. Schools.
14.		"Oilseeds and Feeding Cakes" ..	Imperial Institute, London.
15.		"Oilseeds, Oils, Fats & Waxes"	Do.
15A.		Colonial Reports (Miscellaneous).	Do.

16.		"Quarterly Reports of Imperial Institute."	Do.
17.		"Oil content of some South Indian Oilcakes." Journal of Indian Institute of Science, Vol. 1, Part XIX.	Mysore Residency Press.
18.		"Oil Splitting by Castor Seed Lipase." Journal of Indian Institute of Science, Vol. 2, Part XV.	Do.
19.	Koppe, S. W.	"Glycerine"	Scott Greenwood & Co.
20.	Lamborn, L. L.	"Cottonseed Products" ..	Do.
21.	Do.	"Soaps"	Do.
22.	Lewkowitch, D. J.	"Chemical Technology & Analysis of Oils, Fats and Waxes." 3 Vols.	MacMillan & Co.
23.	Noel Paton, F.	"Indian Cottonseed; Its Industrial Possibilities."	Superintendent, Government Printing, Calcutta.
24.	Pandit, Y. G.	"Report on Oil Pressing Industry of Bombay Presidency.	Bombay Government Central Press.
25.	Simmons, W. H. and Mitchell, C. A.	"Edible Fats & Oils	Scott Greenwood & Co.
26.	Watt, Sir George	"The Commercial Products of India."	John Murray.
27.	Wright, C. R. Alder	"Animal and Vegetable Fixed Oils, Fats and Waxes."	
28.		"Minutes of Evidence of the Committee on Edible Oil Producing Nuts & Seeds of West Africa."	H. M. Stationery Office, London.

APPENDIX No. IV.

Average oil content of some English oil-cakes as given by Professo Crowther, M.A., Ph.D., Director of the Institute for Research i Animal Nutrition in the University of Leeds, in a memorandun submitted to the Committee on Edible and Oil Producing Nuts an Seeds (1916).

No.	Variety.	How prepared.	Average oil content.
1	Palm kernel cake ..	Hydraulic Press ..	6 per cent.
2	Coconut cake ..	Do. ..	10 „
3	Groundnut cake ..	Do. ..	10 „
4	Linseed cake ..	Do. ..	10 „
5	Decorticated cotton seed cake.	Do. ..	9 „
6	Undecorticated cotton seed cake.	Do. ..	5·5 „

APPENDIX No. V.

Average oil contents of some American oil-cakes as given by Henry and Morrison in "Feeds and Feeding" (1917 Edition).

No.	Variety.	How prepared.	Average oil content.	Number of samples analysed.
1	Cotton seed cake and meal choice ..	Hydraulic Press, decorticated ..	9·1 per cent. ..	2,556
2	Do. prime ..	Do. do. ..	8·3 „ ..	1,322
3	Do. good ..	Do. do. ..	8·2 „ ..	482
4	Do. ..	Expeller, undecorticated ..	7·7 „ ..	64
5	Linseed cake and meal	Hydraulic Press	7·5 „ ..	714
6	Linseed meal	Extracted	2·9 „ ..	182
7	Groundnut cake	Hydraulic Press, decorticated ..	8·0 „ ..	2,480
8	Do.	Do. undecorticated ..	11·1 „ ..	7
9	Coconut cake and meal	Hydraulic Press	11·3 „ ..	11
10	Palmnut cake	Do. ..	9·5 „ ..	600
11	Rape seed cake	Do, ...	9·6 „ ..	500
12	Sesamum or tilcake	Do.	14·00 „ ..	150

APPENDIX VI.

Extraction of Oils by Solvents.

FROM THE OIL AND COLOUR TRADES JOURNAL OF MARCH 19, 1921.

The second lecture by Mr. R. A. Bellwood (of Rose, Downs Thompson, Ltd.), on "The Extraction of Oils by Volatile Solvents was delivered at the College of Technology, Manchester, on Marc 10. An interesting and extremely valuable feature of the lectur was the section devoted to the design and construction of oil ex traction works utilising the process which was the subject of Mr. Bell wood's remarks.

The lecturer stated that, though a great deal of progress ha been made in recent years, there still existed in this country prejudice against solvent extraction plants when edible oils wer required. Provided that the process were properly carried out, i had been proved, however, that oils produced by solvent extractio were quite suitable for edible purposes. Moreover, many chemist were of opinion that extracted oils were much easier to refine tha ordinary expressed oil. One argument that had been used agains extraction was that a solvent extracted oil contained more free fatt acids than an expressed oil, but such was not the case. The us of a solvent did not increase the fatty acid content, and if mor fatty acids were found in a solvent extracted oil it was simply du to the fact that the raw material had not been of equal quality t begin with. Another objection that was sometimes met with wa the great risk run in using an inflammable solvent, such as petroleum spirit. Provided, however, that a plant was properly constructed and properly worked, very little danger existed. Notwithstanding this prejudice, there had been great developments in the process. Large plants were now at work, in Hull, Liverpool, Warrington, London, Port Sunlight, and Manchester, the aggregate capacity being between 7,000 and 8,000 tons of oleaginous seeds weekly. Manufacturers were beginning to realise the fact that with the solvent process practically the whole of the oil could be extracted. At the present time, the only drawback was the high price of the solvent. That, however, was bound to be reduced, which would give the solvent

tion plants a better opportunity of coming to the front. The and oils that could be treated in a properly designed extraction were so numerous that there was a very wide scope indeed for terprising manufacturer in the future.

'o those about to enter the extraction business, the first thing sider was a suitable site for the necessary buildings. An ɔosition was one where both water and railway accommodation ɔe made available. When choosing a site, it should be borne d that there should be room for expansion purposes. Where ccommodation was available, the seed could be brought up in and delivered to silos by elevators. In designing a new ɜpecial attention should be paid to the handling and trans- ; of the raw materials and the finished products. As regards ldings themselves, the lecturer recommended these to be of ɔf construction throughout, the silos being preferably of con- The ventilation of an extraction house was a very important n, and should be studied very carefully. Whatever solvent d, whether inflammable or non-inflammable, ample provision be made for taking away any vapour caused by leaky ɔr any other cause. Some solvent vapours, though non-in- ble, were detrimental to health, some which were inflammable ıly slightly detrimental, while others were both inflammable ırious. Although the vapours of most of the solvents used ıction works were heavier than air, and tended to sink to r, much of the vapour was carried away if the top of the ɔn house was provided with a ventilator louvre running the ɜngth of the building. It was necessary, however, to have of ventilators at the floor level, which would take away any that could not get away otherwise. Extraction houses should usually were, of lofty construction, with top louvres as d. In buildings so constructed it was usually difficult to y smell of the solvent being used.

vent extraction plants should be well lighted, so that de- ght be easily seen and quickly remedied. All the main cables ɔe carried in steel tubes on the walls outside the building. ɜr possible, all lamps should be of the air-tight bulkhead type,

extraction plants a better opportunity of coming to the front. The seeds and oils that could be treated in a properly designed extraction plant were so numerous that there was a very wide scope indeed for the enterprising manufacturer in the future.

To those about to enter the extraction business, the first thing to consider was a suitable site for the necessary buildings. An ideal position was one where both water and railway accommodation could be made available. When choosing a site, it should be borne in mind that there should be room for expansion purposes. Where water accommodation was available, the seed could be brought up in barges and delivered to silos by elevators. In designing a new plant, special attention should be paid to the handling and transporting of the raw materials and the finished products. As regards the buildings themselves, the lecturer recommended these to be of fireproof construction throughout, the silos being preferably of concrete. The ventilation of an extraction house was a very important problem, and should be studied very carefully. Whatever solvent was used, whether inflammable or non-inflammable, ample provision should be made for taking away any vapour caused by leaky joints, or any other cause. Some solvent vapours, though non-inflammable, were detrimental to health, some which were inflammable were only slightly detrimental, while others were both inflammable and injurious. Although the vapours of most of the solvents used in extraction works were heavier than air, and tended to sink to the floor, much of the vapour was carried away if the top of the extraction house was provided with a ventilator louvre running the whole length of the building. It was necessary, however, to have series of ventilators at the floor level, which would take away any vapours that could not get away otherwise. Extraction houses should be, and usually were, of lofty construction, with top louvres as described. In buildings so constructed it was usually difficult to notice any smell of the solvent being used.

Solvent extraction plants should be well lighted, so that defects might be easily seen and quickly remedied. All the main cables should be carried in steel tubes on the walls outside the building. Wherever possible, all lamps should be of the air-tight bulkhead type,

with water seal, these being let into the walls of the building and connected to the mains outside the building by short branch pipes. As a rule, a plentiful supply of light could be obtained by that method. Where this was not possible, similar lamps might be arranged on the ceiling, all the cables being enclosed in steel tubes. All repair work on the extraction pots should be carried out by the aid of an ordinary battery lamp of good construction.

To obtain the most economical results from an extraction plant, it was essential, said the lecturer, that the type of motor to be installed should have very careful consideration. If the solvent used was an inflammable one, the motors should be arranged outside the extraction house in a vapour-tight building. Most manufacturers preferred an ordinary steam-engine, and took part of the exhaust steam to the extraction house to be used in the solvent evaporators for vapourising the solvent from the oil. Whatever type of driving power was selected, it was necessary to have a boiler for steam production, the steam being essential for distilling off the solvent used from both the oil and the meal. In some plants steam was required for special heaters which drove off a certain percentage of moisture from the raw material before it went to the extraction plant. Steam might also be required for operating drying machines, and also for treating the oil or grease residues. It was usually the practice in designing extraction plants to provide a boiler with a steaming capacity above the actual average steam consumption of the plant. That was a wise precaution, because if anything went wrong, the proper working cycle of the plant was disarranged, with the natural consequence that an abnormal quantity of steam was required at some given period, so as to bring the working back to its proper cycle without loss of time. It might be, when first starting work on a new material, that the estimated time required for extraction might not work out according to calculation, or temporary stoppages might be caused through iron getting into some part of the grinding plant. Even with the most carefully designed plants, and with the best magnetic separators that might happen. To get the best results from a plant, a small recording meter should be fixed to each separate unit, so that it might be definitely ascertained when and where the steam was being consumed.

It was impossible to lay too much stress on a proper preliminary treatment of the material before extraction. All oleaginous seeds or nuts contained greater or lesser quantities of foreign matter, such as stones, iron, sand, and seeds other than those it was intended to treat. If the seeds were not properly cleaned, an inferior oil was obtained, and in some cases the process was retarded, and a smaller percentage of oil obtained on account of the absorbent qualities of the impurities. The theory of extraction was that if ground oleaginous seed was taken and saturated with a solvent, the oil diffused into the solvent, and penetrated into the cells, so that there was a concentrated mixture both in and out of the cells. If, therefore, the quantity of oil in the material being treated was previously known, the amount of the solvent measured, and the amount of mixture run off from the extraction vessel measured, the amount of oil remaining in the material could easily be calculated, as could also the amount of solvent required to bring the oil down to any desired percentage. Briefly explained, the extraction process consisted in : (1) the preparation of the material so that the solvent would pass easily into it, and into the oil cells ; (2) to allow cold or hot liquid solvent or hot vapour to percolate through the material which was contained in an enclosed pan ; (3) to drain off the mixture of oil and solvent from the material into a still ; (4) to drive off the solvent from the oil by heat, as a vapour, and pass through a condenser to liquify and recover the solvent for further use ; (5) to drive off the solvent from the meal by heat, as a vapour, and pass through a condenser to recover as a liquid for future use.

Discussing at some length the ideal solvent material, Mr. Bellwood said the conditions laid down were very exacting indeed : (1) it should neither be inflammable nor expensive ; (2) it should vapourise with the use of only a small amount of heat ; (3) it should dissolve only the oil content of the material under treatment ; (4) it should be of a very searching nature ; (5) it should be a uniform chemical body that would not disintegrate when being distilled off ; (6) it should not give off noxious vapours that would be detrimental to the health of the worker ; (7) it should not cause any chemical change in the material under treatment ; (8) it must not cause deterioration in the

apparatus ; (9) the cost must be low. Needless to say, there was no solvent known that fulfilled all these conditions. Of the many different kinds of solvent materials, only trichloroethylene and carbon tetrachloride could be regarded as safe from explosion and fire. Leaving out the question of specific gravity, carbon tetrachloride was the most favourable as regards the consumption of heat units, both its specific heat and vapourising heat being the lowest. Owing, however, to its higher cost and detrimental effect upon the worker it had been superseded by benzine. The weight of benzine used as against other solvents was as follows :—Compared with carbon tetrachloride 45·9 per cent. ; compared with trichloroethylene, 50·0 per cent. ; compared with carbon bisulphide, 57·2 per cent. ; compared with benzole, 84·0 per cent. The comparative cheapness of benzine and the fact that it was easy to obtain in large quantities should be taken into consideration. It was therefore not difficult to see why benzine was to-day the chief solvent used for extraction purposes.

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